SECTION

III

Future Conditions and Directions

Preface

Sections I and II have described water resource conditions within the Tucson Active Management Area (AMA) and the regulatory programs designed to cause efficient use of groundwater and increasing use of renewable water supplies. The Arizona Department of Water Resources' (Department) regulatory program for the third management period, described in Section II, represents the midpoint in our overall management strategy to implement water management programs which ultimately will lead to the achievement of the AMA's management goal by the year 2025.

Section III describes projected future conditions within the Tucson AMA, as well as the directions the Department proposes to take in developing additional water management programs during the third management period.

Alternative future water supply and demand conditions are described in Chapter 11. The Department's supply and demand conditions, also known as "water budgets," are designed to illustrate a range of supply and demand possibilities for consideration as we develop our management programs. Both Tucson AMA scenarios exhibit overdraft conditions. Chapter 11 projects continued overdraft even under optimistic conditions, indicating that mid-course changes in direction may be necessary if we are to achieve safe-yield by 2025.

Chapter 12 describes some options for the future looking towards ultimately achieving the AMA management goal through increasingly stringent requirements for the conservation of groundwater along with the augmentation of water supplies. Chapter 12 summarizes existing water management problems, identifies the obstacles to safe-yield, and describes the actions the Department expects to take to remove these obstacles during the Third Management Period and beyond.

CHAPTER

11

Water Budgets and Projections

11.1 INTRODUCTION

The basic goals and structure of the water budget are described in the following sections. Terminology and concepts used throughout this chapter that apply to agricultural, municipal, and industrial sector water use are described in chapters 4, 5, and 6, respectively. Terminology and concepts that apply to the recharge and recovery of renewable water supplies are described in Chapter 8. Detailed information on the data sources and projection calculations used in this chapter is compiled in the Third Management Plan Administrative Record.

11.1.1 Use of Water Budgets and Sensitivity Analysis

The Arizona Department of Water Resources (Department) uses detailed water budgets to evaluate the current imbalance between water demands and supplies and to forecast progress toward meeting the Tucson Active Management Area (AMA) goal of achieving safe-yield in the AMA by 2025. Water demand and supply projections and water budget scenarios are prepared based on many assumptions. Two primary water budget scenarios are discussed below. Progress toward meeting safe-yield is tabulated for these budgets in five-year increments through 2025. In addition, sensitivity analyses were performed on selected variables in the water budget to determine the relative impact of these variables on water use in 2025.

11.1.2 Water Accounting Approach Used in the Water Budget

Water is a physical resource and, as such, can be tracked and understood in purely physical terms. However, water management is becoming increasingly tied to legal accounting mechanisms for water supply and demand. The water budgets and sensitivity analyses presented in this chapter incorporate the water accounting approaches used to track the recharge and recovery of Central Arizona Project (CAP) water and effluent, the use of "allowable mined groundwater" under the Assured Water Supply Rules (AWS Rules), and the use of remediated groundwater under the Water Quality Assurance Revolving Fund (WQARF) legislation.

This accounting-oriented water budget, which includes estimates of both "actual" and "accounting" overdraft, does not yield the same estimates of overdraft as would result from a strict hydrologic water budget because in both "actual" and "accounting" overdraft calculations, CAP and effluent recharge volumes are entered as supplies in the water budget only in those years in which they are recovered, even though the water may physically be recharged before this time period and in larger volumes than are recovered. This approach prevents an underestimate of groundwater mining in the early years when recharge may exceed credit recovery and prevents an overestimate of groundwater mining in later years when recovery of credits may exceed recharge.

After "actual overdraft" is calculated, "accounting overdraft" is determined by subtracting the volume of allowable mined groundwater and remediated groundwater projected to be used in a given year from actual overdraft. The various types of mined groundwater, including allowable mined groundwater and remediated groundwater, are described in section 11.4.1.2.

When groundwater is pumped as a means to recover CAP or effluent recharge credits, it is shown as CAP water or effluent in the water budget. For example, under the Groundwater Savings Program, CAP water is applied directly to agricultural land in place of the groundwater the farmer otherwise would have used. CAP credits are accrued by the entity (a water provider, Central Arizona Water Conservation District (CAWCD), Central Arizona Groundwater Replenishment District (CAGRD), Arizona Water Banking Authority (AWBA), etc.) that supplies CAP water to the farmer at a subsidized cost. For Department water accounting purposes, the farmer who applies CAP water to his fields is still considered to be using groundwater, so his use is shown as groundwater in the water budget. When the CAP credits are recovered in the future through the process of pumping groundwater, this water is shown as CAP water in the water budget.

The water budget does not reflect the impacts of recharge and pumping on water levels in the AMA. The Department is developing a computer model that will make it possible to map areas of projected water level rises and declines in order to show the impacts of recharge and pumping inside the AMA.

11.1.3 The Third Management Plan and the Water Budget in the Context of Longer-Term Water Management

The overdraft values shown in the water budget represent AMA-wide balances at given points in time. The third management period constitutes one ten-year increment of the 35-year time period represented in the water budget. Both the management plan and the water budget are affected by the requirements and implications of the Assured Water Supply Program (AWS Program) and need to be understood in the context of the 100-year planning time frame addressed by the AWS Program. Many of the decisions water providers will make between now and 2025 will be made in the context of water management needs during this 100-year time frame. Likewise, decisions the Department makes on water management policy are framed in this larger context, including the decision to allow a certain volume of groundwater mining by water providers.

11.1.4 Complexity of Supply and Demand Components in the Water Budget

The major components of water supply and demand in the Tucson AMA are illustrated in Figure 11-1. The water budget must account for a variety of supply and demand components and a number of complicating factors including time lags between CAP and effluent storage and recovery, allocations of water to the aquifer (cuts to the aquifer) as a result of CAP and effluent recharge, and multiple categories of groundwater use that are accounted for differently in the budget. Supply and demand components are described in detail in this chapter.

11.2 WATER BUDGET SCENARIOS

Two water budget scenarios are presented in this plan. These scenarios were selected from numerous scenarios prepared by the Department to illustrate possible water demand and supply conditions and to demonstrate the projected effects of Third Management Plan conservation requirements on reducing water use in the Tucson AMA. The water budget scenarios are as follow:

- **Base Scenario**: Assumes that, while the municipal population and the number of industrial facilities grow through 2025, the municipal gallons per capita per day (GPCD) water use rates and industrial water use practices present in 1995 continue through the year 2025.

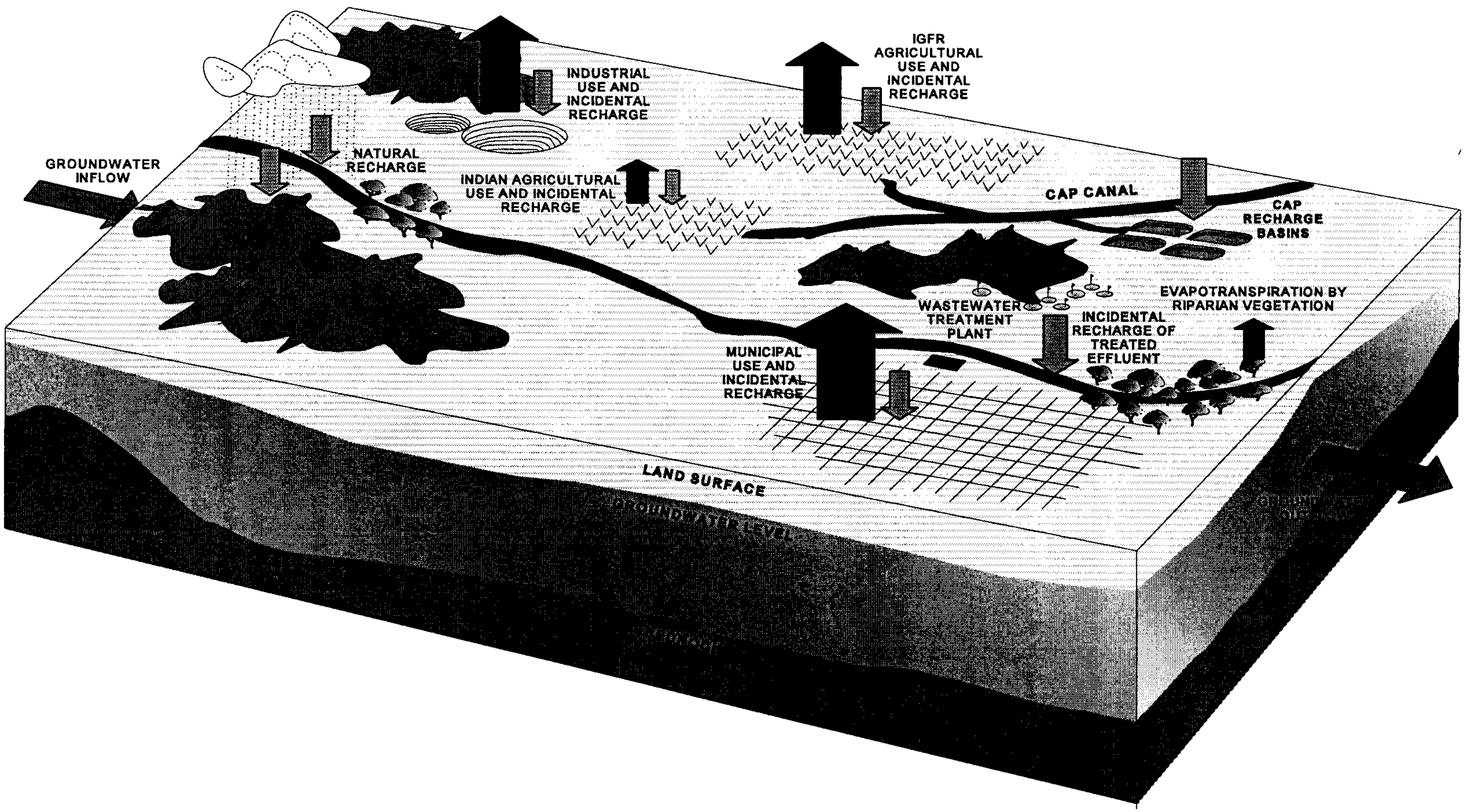
- **Third Management Plan Scenario (TMP Scenario)**: Assumes that, while the municipal population and the number of industrial facilities grow through 2025, municipal and industrial demand levels are reduced to meet Third Management Plan conservation requirements and these reduced demand levels continue through 2025. This scenario also assumes that some AWBA CAP recharge credits are extinguished to benefit the aquifer.

The following general assumptions apply to both water budget scenarios:

- Tucson AMA population projections are based on Department of Economic Security projections.

- Turf-related facility demand served by municipal providers increases over time based on projected expansion of existing facilities and projected construction of new facilities.

FIGURE 11-1
SCHEMATIC ILLUSTRATION OF DEMAND AND SUPPLY VARIABLES
IN THE WATER BUDGET
TUCSON ACTIVE MANAGEMENT AREA



- Agricultural demand decreases over time as a result of a reduction in irrigation acres as agricultural lands are retired to other uses; agricultural water use efficiency increases as a result of implementation of improved water management practices that are not related to Third Management Plan requirements.

- Industrial water demand increases on an industry-by-industry basis through 2025 based on one or more of the following factors: (1) past history of growth, (2) growth projections provided by the industrial water users and evaluated by the Department, and (3) parallels to population growth.

- The volume of CAP recharge tallied in water budget scenarios in any given year is equal to the sum of the annual storage and recovery credits projected to be recovered that year, the long-term storage credits projected to be recovered that year, the CAGRD replenishment obligations incurred that year, and a 5 percent cut to the aquifer associated with long-term storage credits and replenishment obligations. CAP recharge does not appear in the budget if it results in the accumulation of long-term storage credits that are not recovered by 2025.

- A portion of effluent discharged from Pima County's regional wastewater treatment plants into the Santa Cruz River is stored through managed in-channel effluent recharge projects by the City of Tucson and the United States Secretary of the Interior, and a portion of these credits are recovered.

Groundwater pumped within the AMA on Indian reservations is not regulated by the Department but is tracked in the water budget. Specific demand and supply assumptions used in water budget scenarios are described in the following sections.

11.3 PROJECTED DEMAND BY SECTOR

Water demand in the Tucson AMA is divided into municipal, agricultural, and industrial sectors for analysis and management purposes.

11.3.1 Agricultural Demand Assumptions

Agricultural water demand on non-Indian lands is a function of the land actually cultivated in a given year as it relates to the total acreage that can legally be irrigated (the cropped-acreage ratio). Non-Indian irrigated acreage is served by groundwater, with the exception of a small volume of effluent use each year. Cultivation on Indian lands is not subject to the legal restrictions on irrigable acreage that apply on non-Indian lands. Indian irrigation is expected to be served by importation of CAP water. Water demand for irrigation both on and off Indian lands is affected by the efficiency of water use and the average consumptive use of crops. Components of agricultural demand for each water budget scenario are shown in Table 11-1. More information on agricultural water use and explanations for the terms used here are contained in Chapters 3 and 4.

Agricultural water use variables and assumptions stay constant for both scenarios, and include the following:

- Irrigation grandfathered right (IGFR) acreage decreases by 50 percent from 1995 to 2025
- Irrigation efficiency increases from 75 percent to 80 percent starting in 2010 for non-Indian agriculture
- Cropped acreage ratio increases to 65 percent by 2005 for non-Indian agriculture
- Agricultural effluent use averages 3,000 acre-feet per year from 2000 to 2025 for non-Indian agriculture
- Canal loss of 7 percent for Cortaro Marana Irrigation District (CMID) canals
- Average consumptive use of 3.6 acre-feet/acre for both Indian and non-Indian agriculture

- Demand for 10,300 acre-feet/year of CAP water by 2005 and 15,800 acre-feet/year of CAP water by 2010 to irrigate lands on the San Xavier and Schuk Toak Districts of the Tohono O'odham Nation
- 75 percent irrigation efficiency for Indian agriculture
- Cropped acreage ratio of 100 percent for Indian agriculture

TABLE 11-1
AGRICULTURAL DEMAND ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Agricultural Water Use Projections							
	1990	1995	2000	2005	2010	2015	2020	2025
Non-Indian Irrigation								
Total IGFR Irrigation Demand (AF)[1]	93,800	98,000	103,600	107,400	91,700	81,200	69,200	54,200
IGFR Acreage (acres)	40,000	36,100	35,100	33,600	30,600	27,100	23,100	18,100
Cropped Acreage Ratio	47%	55%	60%	65%	65%	65%	65%	65%
Consumptive Use Factor (AF/acre)	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Irrigation Efficiency	75%	75%	75%	75%	80%	80%	80%	80%
Agricultural Effluent Use (AF)	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Irrigation District Canal losses (AF)	3,000	3,400	2,600	2,700	2,300	2,100	1,700	1,400
Indian Irrigation								
Total Indian Irrigation Demand (AF)	0	0	1,100	10,300	15,800	15,800	15,800	15,800
Total Indian Irrigation Acreage (acres)	0	0	220	2,150	3,300	3,300	3,300	3,300
San Xavier	0	0	220	1,000	1,000	1,000	1,000	1,000
Schuk Toak	0	0	0	1,150	2,300	2,300	2,300	2,300
Cropped Acreage Ratio	100%	100%	100%	100%	100%	100%	100%	100%
Consumptive Use Factor (AF/acre)	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Indian Irrigation Efficiency	75%	75%	75%	75%	75%	75%	75%	75%

[1]Total IGFR irrigation demand includes canal losses and irrigation use by exempt small rights
IGFR = Irrigation Grandfathered Right
AF = acre-feet

A finite number of IGFR acres exist in the Tucson AMA, limited by the Groundwater Code (Code) to the acreage that was irrigated from 1975 to 1980. Maximum irrigable acreage is projected to decrease by approximately 50 percent between 1995 and 2025 as agricultural land shifts to other types of use and development. A previous large reduction in irrigated acreage occurred on 16,000 acres of farmland bought and retired by the City of Tucson between 1975 and 1986 to obtain the associated water rights. Shifts away from agricultural use in the future could occur in several areas of the AMA. In the northern Marana area, shifts away from agricultural land use are likely due to improved flood control protection along the Santa Cruz River, which will allow urban development of formerly flood-prone agricultural land. Shifts away from agricultural land use could also occur due to development of portions of Farmers Investment

Company acreage in the Green Valley/Sahuarita area and development of some remaining agricultural acreage along the Interstate 10 corridor east of the Tucson Mountains.

The cropped acreage ratio for IGFRs is assumed to increase from 47 percent in 1990 to 65 percent by 2005 and to continue at 65 percent through 2025. The increasing cropped acreage ratio reflects several factors including the phasing out of government subsidies to reduce acreage in production and increases in irrigation that may result from other economic conditions. As the number of IGFRs decrease in the AMA, it is assumed that a larger percent of the remaining farmland will be kept in production. This projected increase in the cropped acreage ratio results in an increase in agricultural demand in 2000 and 2005, even though IGFR acreage is projected to decrease during this period.

It is estimated that groundwater irrigation will serve approximately 220 acres of farmland on the San Xavier District of the Tohono O'odham Nation by the year 2000. By 2005, it is projected that CAP water will replace this groundwater use and additional acreage will be brought into production, reaching a total of approximately 1,000 acres. The Schuk Toak District of the Tohono O'odham Nation is projected to be irrigating approximately 1,150 acres of land with CAP water by 2005 and 2,300 acres by 2010, continuing through 2025. Total Indian agricultural water use is projected to increase from around 10,300 acre-feet in 2005 to 15,800 acre-feet in 2010.

The consumptive use value is the volume of water used by plants for growth and transpiration. A consumptive use value of 3.6 acre-feet/acre/year is used for both Indian and non-Indian agriculture in the water budgets. This is an average value based on existing consumptive use values in the AMA and is assumed to apply to all crops for all years in the water budget.

Second and Third Management Plan conservation requirements for irrigation right holders are generally based on an assigned irrigation efficiency that is used to determine a maximum annual groundwater allotment. The allotments are based on the crops historically grown and the highest number of acres planted in any one year from 1975 to 1980. The Department does not require farmers to operate at their assigned irrigation efficiency. However, they must meet their assigned maximum annual groundwater allotment.

For purposes of the water budget, an assumed irrigation efficiency of 75 percent is projected to increase to 80 percent by 2010 and continue at this level through 2025 for non-Indian agriculture. This increase is expected to result from several factors. Water management assistance programs provided by the Department through avenues other than the management plans will assist farmers in improving irrigation efficiency. In addition, the relationship between the cost to use water and profit margins will act as an incentive to improve efficiencies. It is assumed that Indian irrigation water use efficiency will remain at 75 percent through 2025. The Department's agricultural conservation requirements and the flexibility account provisions associated with IGFRs are not applicable to Indian agricultural systems.

The average use of effluent since 1988 by the agriculture sector has been around 3,000 acre-feet per year. Although this could change if new effluent delivery projects are implemented, current assumptions are that this level of use will continue through 2025. A canal loss of approximately 7 percent is applied to water used in the CMID, which relies on extensive distribution canals to supply water to a number of farms. This value is added to on-farm water use to derive total irrigation demand.

11.3.2 Municipal Demand Assumptions

Population and per capita water consumption are the primary factors influencing municipal demand. Total municipal demand is composed of potable and non-potable water use by AMA water providers, domestic well owners, and Indian reservation populations. Municipal demand is currently met by groundwater and by effluent, some of which is delivered through the City of Tucson's reclaimed water system to municipal turf-related facilities (golf courses, parks, cemeteries, school yards, etc.). In the Third Management Plan, future demands are assumed to be met with decreasing amounts of groundwater and with increasing amounts of directly used effluent, recharged and recovered effluent, and recharged and recovered CAP water. Components of municipal demand for each water budget scenario are shown in Table 11-2. Additional information on municipal water use is contained in chapters 3 and 5.

Municipal water use factors that stay constant for both scenarios are:

- Projections of AMA population
- Demand of 50 GPCD on the San Xavier District and the portion of the Schuk Toak District that is within the Tucson AMA
- Municipal demand for secondary effluent and reclaimed water

The municipal water use factor that changes between the two scenarios is average non-Indian municipal demand. The assumptions about this factor are:

- Demand of 172 GPCD in 1995 in the Base Scenario continuing through 2025
- Demand of 172 GPCD in 1995 decreasing to 161 GPCD by 2010 and to 158 GPCD by 2025 in the TMP Scenario

Total municipal demand in 1995 was 155,500 acre-feet (Table 11-2). In the Base Scenario, it is projected that total municipal demand will reach 267,100 acre-feet in 2025. In the TMP Scenario, municipal demand is projected to reach 247,300 acre-feet in 2025. The population of the AMA, with the exception of Indian districts, was approximately 766,500 in 1995 and is expected to reach around 1,262,900 by 2025 based on Department of Economic Security projections. The population on the San Xavier District and the portion of the Schuk Toak District that is within the AMA was approximately 1,500 in 1995 and is expected to reach approximately 3,600 by 2025 based on an assumed growth rate of 3 percent per year. The population of the Pascua Yaqui Reservation is included in non-Indian AMA population estimates because this area is served by Tucson Water.

It is assumed in the Base Scenario that municipal GPCD conditions present in 1995 remain in place through 2025. It should be noted that under the Second Management Plan requirements, municipal GPCD would continue to decrease through 2025 as it does under the Third Management Plan requirements. Municipal water demand averaged 172 GPCD in 1995. Municipal water demand in 2010 is projected to average 172 GPCD under the Base Scenario and 161 GPCD under the TMP Scenario reflecting reduced use due to Third Management Plan conservation requirements. Because Third Management Plan conservation requirements specify that new municipal water users meet a lower GPCD rate than existing users, the total GPCD for the TMP Scenario continues to go down after 2010. The GPCD reaches 158 in 2025 reflecting the effect of newly added population.

Municipal demand projections are based on the average GPCD rates that would need to be achieved under the Total GPCD Municipal Conservation Program. Several large water providers including Tucson Water have requested transfer out of the Total GPCD Program and into the Non-Per Capita Program. In the Non-Per Capita Program, GPCD targets are not specified for water providers, but water conservation strategies should result in savings equivalent to those in the Total GPCD Program. The components that are used to calculate average GPCD are residential, non-residential, and lost and unaccounted for water use. Residential use applies to single and multifamily homes and apartments. Non-residential use applies to industries, turf-related facilities, and other non-residential users served by water providers. Lost and unaccounted for water results from leaking pipes, hydrant use, and other losses.

TABLE 11-2
MUNICIPAL DEMAND ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Municipal Water Use Projections							
	1990	1995	2000	2005	2010	2015	2020	2025
Total Municipal Demand, Base Scenario (AF)[1]	130,100	155,500	172,900	193,500	212,200	232,000	249,700	267,100
Total Municipal Demand, TMP Scenario (AF)[1]	130,100	155,500	172,900	188,300	199,800	218,600	233,900	247,300
AMA Population Off-Reservation	653,700	766,500	836,600	919,000	1,003,000	1,089,600	1,176,100	1,262,900
Indian Reservation Population	1,300	1,500	1,700	2,000	2,300	2,700	3,100	3,600
Municipal Demand (GPCD)								
Base Scenario	169	172	172	172	172	172	172	172
TMP Scenario	169	172	172	167	161	161	160	158
Indian Reservation Demand (GPCD)	50	50	50	50	50	50	50	50
Municipal Secondary Effluent/Reclaimed Demand (AF)	6,300	7,700	11,600	16,300	18,800	21,900	23,000	23,600

[1]Municipal demand includes pumpage from exempt wells
AF = acre-feet
TMP = Third Management Plan
AMA = Active Management Area
GPCD = gallons per capita per day
Note: Indian Reservation population includes the San Xavier District, and the portion of the Schuk Toak District within the AMA boundary. It does not include the Pascua Yaqui Reservation population, which is served by Tucson Water and is included in the AMA off-reservation population.

Exempt well users are included in the municipal population estimates. Since exempt well use (wells with pump capacities of <35 gallons/minute) is not reported to the state, it is assumed for purposes of the water budget that exempt well water use per person is the same as the average municipal water use rate. Water demand on the Schuk Toak and San Xavier Districts was approximately 50 GPCD in 1995 and is projected to continue at this level through 2025.

In 1995, 7,700 acre-feet of secondary effluent and reclaimed water were used to meet municipal sector demands primarily for turf-related facility use. Municipal demand for effluent is projected to reach 23,600 acre-feet by 2025. Because this municipal effluent demand is not a component of the GPCD calculations made by the Department, municipal demand for secondary effluent and reclaimed water is tabulated separately from the GPCD-based demand in the water budget and then added to GPCD-based demand to determine total municipal demand.

Shortly after the year 2000, managed in-channel recharge of effluent is projected to commence. The effluent proposed for recharge is controlled by the City of Tucson and the United States Secretary of the Interior. Managed effluent recharge is proposed in the bed of the Santa Cruz River. Credits accrued from this process are anticipated to be recovered to meet a portion of the City's reclaimed water system demand and to support the settlement of Indian water rights claims of the Tohono O'odham Nation. Recovery of effluent credits to meet a portion of the City's reclaimed system demand is incorporated in secondary effluent and reclaimed demand estimates shown in Table 11-2. Additional credits are anticipated to be recovered by water providers, who would recover credits by pumping groundwater from other locations of the AMA. It is assumed that, for these water providers, recovered effluent credits would replace a portion of their use of recovered CAP credits. Projections of the accrual and recovery of effluent credits and the impact of this recharge effort on incidental recharge in the river are discussed and tabulated in section 11.4.2.

11.3.3 Industrial Demand Assumptions

For purposes of the water budget, all water demand for industrial facilities served completely or partially by Type 1 or Type 2 non-irrigation groundwater rights and groundwater withdrawal permits is tallied under the industrial sector. This includes secondary effluent and reclaimed water demand at those industrial facilities that have converted or are projected to convert from groundwater to effluent supplies. Components of industrial demand are shown in Table 11-3 for industrial turf-related facilities, metal mining facilities, and the combined use of other industrial facilities. More information on industrial water use is contained in Chapters 3 and 6.

TABLE 11-3
INDUSTRIAL DEMAND ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Industrial Water Use Projections (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Industrial Turf-related Facilities								
Both Scenarios -Groundwater	6,300	7,200	8,100	8,100	7,800	6,000	5,900	5,800
Both Scenarios - Effluent	800	800	1,100	1,300	2,300	2,800	3,200	3,500
Metal Mining								
Base Scenario - Groundwater	32,400	41,400	47,500	47,500	47,500	47,500	47,500	47,500
TMP Scenario - Groundwater	32,400	41,400	47,500	47,500	47,000	47,000	47,000	47,000
Other Industrial								
Base Scenario - Groundwater	9,200	10,900	14,100	14,860	15,610	16,370	17,170	17,940
TMP Scenario - Groundwater	9,200	10,900	14,100	14,860	15,560	16,310	17,110	17,870
Both Scenarios - Effluent	0	0	200	400	600	800	1,000	1,200

TMP = Third Management Plan

Conservation requirements for turf-related facilities and large-scale cooling facilities apply to facilities in both the municipal and industrial sectors. Water demand for turf-related facilities and large-scale cooling facilities served exclusively by municipal providers is tallied under municipal demand.

Industrial demand projections vary depending on conservation requirements and the rate of growth projected for industrial categories. In the Base Scenario, demand for groundwater by metal mines was 41,400 acre-feet in 1995 and is projected to increase to 47,500 acre-feet by 2000 and continue at this level through 2025. Water use by the metal mining industry could vary substantially from projected use because the industry is subject to changes in the world copper market and innovations in copper extraction technologies. The mining industry currently holds allotments for around 62,000 acre-feet of groundwater per year and could obtain additional groundwater withdrawal authority through purchase of groundwater rights or requests for groundwater withdrawal permits, if needed. For purposes of the water budget, conservation requirements in the Third Management Plan are projected to result in a one percent savings in mine water use in the TMP Scenario. These savings begin in 2010 and continue through 2025, when mine water use is projected to be around 47,000 acre-feet per year.

Groundwater use by industrial turf-related facilities was approximately 7,200 acre-feet in 1995. Annual groundwater use is projected to temporarily increase during the years 2000 to 2010 as turf-related facility demand increases, then decrease to around 5,800 acre-feet by 2025 as increasing numbers of turf-related facilities convert from groundwater to effluent water sources. Effluent use by these industrial facilities is projected to increase from around 800 acre-feet in 1995 to around 3,500 acre-feet in 2025, due to the combination of the expansion of existing facilities already using effluent and the conversion from groundwater to effluent at other facilities. Because water allotments for turf-related facilities specified in the Second Management Plan are being maintained in the Third Management Plan, these projections apply to both scenarios.

In the Base Scenario, the combined groundwater use of sand and gravel facilities, electric power plants, and other industrial facilities besides mines and turf-related facilities increases from 10,900 acre-feet in 1995 to a projected 17,940 acre-feet in 2025. Overall, water demand increases due to growth in the size and number of industrial facilities. In the TMP Scenario, groundwater use at sand and gravel facilities is projected to decrease by 1 percent to reflect increasing conservation requirements for this sector in the Third Management Plan. Effluent use by sand and gravel facilities is projected to increase from 0 to 1,200 acre-feet between 1995 and 2025 based on the assumption that some facilities located along the Santa Cruz River will convert from groundwater to effluent use over time.

11.3.4 <u>Other Demands - Evapotranspiration</u>

Evapotranspiration generally occurs along water courses where trees and other vegetation grow and where the water table is shallow enough to be tapped by this vegetation. Evapotranspiration losses are estimated at 3,700 acre-feet per year in the AMA, all of it occurring in the Upper Santa Cruz Valley Subbasin.

11.4 <u>PROJECTED WATER SUPPLIES</u>

Components of the available water supply in the AMA include the following:

- Renewable groundwater sources including net natural recharge and incidental recharge
- Allowable mined groundwater supplies including those allocated under the AWS Program
- Groundwater withdrawn during remediation projects
- Direct use of effluent
- Recharge and recovery of effluent
- Direct use of CAP water for Indian agriculture
- Recharge and recovery of CAP water
- Extinguishment of CAP recharge credits by the AWBA

Water supply estimates are compared to water demand projections to determine the adequacy of these supplies to meet demand. Water users in the AMA currently obtain the majority of their water supply from mined groundwater. Increased utilization of CAP water and effluent are essential to achieving AMA management goals. These renewable supplies can be used directly or can be used indirectly through storage and recovery projects.

Water providers will be making decisions about the volumes of each water supply to use on a year-to-year basis. These decisions are based on a large number of considerations that range from whether groundwater is physically available to pump to whether there are shortages of CAP water. Because of this dynamic decision-making process, it is difficult to project what supplies will be used when. For purposes of the water budget, a series of simplifying assumptions must be made. Water supply assumptions and projections used in the water budget are described in the following sections for groundwater, effluent and CAP water.

11.4.1 Groundwater

A small portion of the groundwater supply is renewable. Renewable groundwater is replaced yearly by precipitation, groundwater underflow, and flow back to the aquifer following human use (incidental recharge). The remainder of the groundwater supply is non-renewable and withdrawal of it, without associated recharge of the aquifer with a renewable water supply, constitutes groundwater mining. Some groundwater mining is allowed by the Department in the context of the AWS Program. Groundwater withdrawals are also allowed under new WQARF legislation as an incentive to pump and treat contaminated water. These categories of groundwater use are described below.

11.4.1.1 Renewable Groundwater

Groundwater supplies in the Tucson AMA are partially replenished by natural recharge to the aquifer originating from net groundwater underflow and infiltration of precipitation, and by incidental recharge originating from municipal, agricultural and industrial water uses that result in water percolating back to the aquifer.

11.4.1.1.1 Net Natural Recharge

Net natural recharge in a given year is the volume of water that naturally recharges the groundwater supply minus the natural depletions to the groundwater supply over the course of that year. The components of net natural recharge that increase the groundwater supply are stream channel infiltration, mountain front recharge, and groundwater inflow into the AMA. The groundwater supply is depleted by groundwater outflow out of the AMA. Net natural recharge in the AMA is estimated at 60,800 acre-feet per year. Components of AMA natural recharge are discussed in Chapter 2 and tabulated in Table 2-1.

11.4.1.1.2 Incidental Recharge

Incidental recharge originates as pumped, imported, or diverted water that percolates down to the water table after it is used for human activity. In the Tucson AMA, the volume of incidental recharge is largely dependent on the extent and efficiency of agriculture, the level of mining activity, and the quantity of effluent discharged into stream channels. Other factors affecting incidental recharge are the level of industrial activity other than mining and the level of water use by the municipal sector. The 4 percent incidental recharge factor for the municipal sector is the only incidental recharge factor that is specified by rules or regulations. It is referenced in the AWS Rules and in the Non-Per Capita Conservation Program as a volume of groundwater that municipal providers need not replenish or find renewable supplies to meet. While the volume of incidental recharge varies somewhat between water budget scenarios due to differences in sector water demand, the percentage rate of incidental recharge for these sectors is the same for both scenarios. Incidental recharge factors used in the water budget are shown in Table 11-4.

11.4.1.2 Mined Groundwater

Because of the detrimental effects that result from groundwater mining in the AMA, including decreasing groundwater levels, subsidence, reduced water quality and increased pumping costs, it is essential that groundwater mining be curtailed to the greatest extent possible. To reduce groundwater use in the long-term, the Department has provided transitional approaches that allow water providers certain limited amounts of groundwater use while they convert to renewable supplies. Groundwater may also be pumped on an ongoing basis by some existing water users pursuant to state regulations, and a specified volume of remediation water may be pumped. These categories of groundwater use are addressed below.

TABLE 11-4
INCIDENTAL RECHARGE ASSUMPTIONS
TUCSON ACTIVE MANAGEMENT AREA

Incidental Recharge Rate	Source of Incidental Recharge
4%	Total municipal demand
90%	Effluent discharged in Santa Cruz River by regional wastewater treatment plants that is not part of managed in-channel effluent recharge projects
20%	Total agricultural demand for agricultural efficiency of 75%
16%	Total agricultural demand for agricultural efficiency of 80%
12%	Mining facility demand
12%	Other large industrial water users

11.4.1.2.1 Allowable Mined Groundwater

The Department has earmarked certain volumes of groundwater for use by water providers who are designated as having an assured water supply and for subdivisions that have a Certificate of Assured Water Supply (Certificate of AWS). These mined groundwater allowances have been provided to help municipal water providers transition from groundwater to renewable supplies, to provide time for the CAGRD to replenish groundwater, and, in conjunction with the use of CAP credits from water recharged by the Arizona Water Banking Authority, to assist in providing a secure water supply in years when there are shortages of CAP water. Such shortages are likely to occur during drought conditions on the Colorado River, which are projected to occur in about one-third of the next 100 years. Projections of the distribution of drought years is skewed toward the latter half of the 21st century. It would be beneficial if designated providers retained groundwater reserves for use in drought years since CAP supplies are currently relatively abundant and could be used instead of allowable mined groundwater.

Under the AWS Program, allowable mined groundwater supplies include the following categories for designated water providers:

- A "phase-in" groundwater allowance equal to 15 times the 1994 demand of the water provider's service area
- A groundwater credit based on the extinguishment of any Type 1 or Type 2 grandfathered rights

An early application incentive of "free groundwater for three years" was extended to providers who applied for an assured water supply by a specified date. The "free groundwater" period extends through 1998 for five out of six of the designated large water providers, and through 2000 for Tucson Water. Therefore, the need to meet demand with renewable supplies or allowable mined groundwater begins in 1999 for most large providers, and in 2001 for Tucson Water.

Groundwater served to subdivisions that are covered by Certificates of AWS that were applied for after February 1995 typically replenish this groundwater through contracts with the CAGRD. The CAGRD is required to replenish a minimum percentage of groundwater use in a given year through recharge of CAP water or effluent. This minimum percentage starts with 1/30 of the subdivision groundwater use in 1995, and increases 1/30 each year through 2014 when the replenishment obligation reaches 20/30 of groundwater use. For purposes of the water budget, it is assumed that the rate of replenishment continues to increase each year and is at 100 percent in 2025. The groundwater volume that is not replenished during this phase-in period is assumed for purposes of the water budget to be allowable mined groundwater.

Allowable mined groundwater is not subject to the replenishment requirements that other mined groundwater is, but its use is subject to conservation requirements. Mined groundwater allowances total approximately 1.9 million acre-feet for the six designated Tucson AMA water providers, including Tucson Water. It is assumed in the water budget that the mined groundwater allowance used in a given year is the volume of groundwater demand in that year for designated water providers and the portion of new growth in certificated subdivisions that has a replenishment obligation. The date at which these requirements commence varies between water providers depending upon when they received their designations or certificates. Allowable groundwater use at five-year intervals through 2025 is projected for each of the water budget scenarios as shown in Table 11-5. Cumulative use over this time period is projected to total around 829,500 acre-feet under the TMP Scenario, leaving a balance of around 1,070,500 acre-feet of the 1.9 million acre-foot allowable groundwater accounts of municipal providers. Projected allowable mined groundwater use increases sharply in the first 10 years of the next century, then levels off. This is because the CAGRD replenishment requirement increases by 1/30 each year, generally offsetting increasing municipal demand for allowable groundwater. The City of Tucson has an additional groundwater allowance as discussed in the next section.

TABLE 11-5
ASSUMED USE OF ALLOWABLE MINED GROUNDWATER BY MUNICIPAL PROVIDERS
TUCSON ACTIVE MANAGEMENT AREA

Water Budget Factor	Projected Use (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Allowable Mined Groundwater - BASE Scenario	0	0	10,000	33,400	37,000	39,200	40,300	41,100
Allowable Mined Groundwater - TMP Scenario	0	0	10,000	32,400	34,500	36,500	37,000	37,000

TMP=Third Management Plan

11.4.1.2.2 City of Tucson Avra Valley Groundwater Allowance

The City of Tucson is statutorily allowed to receive up to 2 million acre-feet of additional groundwater allowance because they purchased and retired over 16,000 acres of active farmland in the Avra Valley in the late 1970s and early 1980s. For purposes of the water budget, it is assumed this water will not be used before 2025 because the statutory formula for the allowance results in an incentive to delay its use; however, there is no prohibition that prevents this water from being used before 2025.

11.4.1.2.3 Pumpage by Existing Users

A certain number of municipal water users in the AMA, those who are not served by designated water providers and who live in subdivisions platted prior to February 1995, are not required under the AWS Program to replace existing groundwater use with renewable supplies. The volume of groundwater pumped by these existing users totals around 22,000 acre-feet per year. This groundwater demand is anticipated to continue through time in the Tucson AMA and is not subject to the existing AWS Program. This water does not have a replenishment obligation associated with it but is subject to conservation requirements.

11.4.1.2.4 Grandfathered Groundwater Rights and Permits

Groundwater is pumped by the industrial and agricultural sectors pursuant to grandfathered groundwater rights and permits. This industrial and agricultural pumpage constitutes a significant portion of the groundwater use in the AMA and is not required to be replenished under current provisions of the Code.

11.4.1.2.5 Remediated Groundwater

In 1997, the Legislature enacted legislation significantly revising the WQARF Program to provide incentives for the use of poor quality groundwater to facilitate the remediation of contaminated groundwater. The WQARF legislation provides that, when determining compliance with management plan conservation requirements, the Department shall account for groundwater withdrawn pursuant to approved remedial action projects under the Comprehensive Environmental Response, Compensation and Liability Act or Title 49 of the Arizona Revised Statutes, in a manner consistent with the accounting for surface water. Laws 1997, Ch. 287, § 51(B). It is assumed in the water budget that between 6,500 acre-feet and 8,400 acre-feet of remediation water will be pumped from the AMA each year from 2000 to 2025 based on the assumption that the Tucson Airport Remediation Project will continue to pump groundwater throughout this time period. This number could increase if additional remediation projects are developed that meet the statutory criteria for the WQARF incentive.

11.4.2 Effluent Supplies

A portion of the effluent produced in the AMA is used for agriculture facilities and for municipal and industrial turf-related facilities. Another portion becomes a source of incidental recharge to the aquifer as a result of being discharged into the Santa Cruz River and infiltrating back to the aquifer. Effluent may also be recharged for annual storage and recovery or for the accumulation and use of long-term storage credits. Recharge may occur through managed effluent recharge projects in the river channel, or through constructed effluent recharge projects. Effluent use approaches are discussed below along with information about their impacts on the water budget. Additional perspectives about the impacts of effluent use approaches on the water budget are shown in the sensitivity analyses in section 11.6.2.

11.4.2.1 Direct Secondary and Reclaimed Effluent Use

Effluent is directly used in two forms in the AMA. Secondary effluent is delivered directly from wastewater treatment plants to agricultural, municipal, and industrial users. Effluent is also diverted from Pima County's Roger Road wastewater treatment plant to the City of Tucson's reclaimed water treatment plant and recharge basins for treatment, storage and eventual delivery through the City's reclaimed water system primarily to serve turf-related uses. Approximately 10,300 acre-feet of effluent were directly used in the AMA in 1995 (Table 11-6). Projections indicate the direct use of around 31,300 acre-feet of effluent in 2025.

In many cases, direct use of effluent requires construction of delivery systems, so its use in the future depends to some extent on the investments made in delivery infrastructure. Around 7,700 acre-feet of effluent were used in 1995 by the municipal sector, which is projected to use 23,600 acre-feet of effluent in 2025. Municipal effluent use consists primarily of reclaimed water use for turf-related facilities but secondary effluent is also used at some facilities. Directly delivered effluent is not subject to municipal GPCD requirements.

Agricultural use of secondary effluent is projected to stay constant at around 3,000 acre-feet per year based on the average annual use by the CMID. There is potential for substantially more agricultural use of effluent if appropriate effluent supplies can be obtained and necessary infrastructure constructed.

Industrial use of effluent was 800 acre-feet in 1995 and is projected to reach 4,700 acre-feet in 2025. Projected industrial use consists primarily of use by turf-related facilities and some projected use by sand and gravel facilities located along the Santa Cruz River. It is assumed the sand and gravel facilities will use the river bed as a conveyance for this secondary effluent.

TABLE 11-6
SECONDARY AND RECLAIMED EFFLUENT SUPPLY ASSUMPTIONS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Projections (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Total Effluent Deliveries	11,100	10,300	15,900	21,000	24,700	28,500	30,200	31,300
Secondary Effluent[1]	6,100	3,400	5,000	5,300	6,200	6,700	7,300	7,600
Reclaimed System Effluent	5,000	6,900	10,900	15,700	18,500	21,800	22,900	23,700
Total Effluent Demand	11,100	10,300	15,900	21,000	24,700	28,500	30,200	31,300
Total Municipal Effluent Demand[2]	6,300	7,700	11,600	16,300	18,800	21,900	23,000	23,600
Turf-related Facilities	5,300	5,900	9,300	13,800	16,100	19,000	19,900	20,300
Other	1,000	1,900	2,300	2,500	2,700	2,900	3,100	3,300
Total Agricultural Effluent Demand	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Total Industrial Effluent Demand	800	800	1,300	1,700	2,900	3,600	4,200	4,700
Turf-related Facilities	800	800	1,100	1,300	2,300	2,800	3,200	3,500
Other	0	0	200	400	600	800	1,000	1,200

[1]Includes secondary effluent from Roger and Ina Road plants and from other outlier plants
[2] Includes secondary and reclaimed water demand only. Does not include effluent credits purchased from Secretary of Interior

Direct delivery of effluent to meet nonpotable water demands in the AMA is of particular benefit when it replaces existing groundwater demand. This reduces groundwater overdraft and leaves more groundwater to meet potable demand. In cases where direct use of effluent is intended to meet future demands that would otherwise be served with groundwater, existing groundwater overdraft is not reduced but increasing future overdraft could be reduced. In cases where the availability of effluent results in new demands being created that would not otherwise have occurred in the AMA, this effluent use is detrimental to the water balance because the effluent will not be available to offset existing or future groundwater pumpage.

11.4.2.2 Incidental Recharge of Effluent

It is estimated that 90 percent of the effluent discharged into the Santa Cruz River from the Ina Road and Roger Road treatment plants reaches the aquifer. This incidental recharge estimate is based on a recent study by the United States Geological Survey of effluent infiltration along the Santa Cruz River. Incidental recharge of effluent discharged to the river bed in 1995 was approximately 50,000 acre-feet (Table 11-7). Future incidental recharge of effluent will decrease as a result of the introduction of managed in-channel effluent recharge projects.

The benefits of direct use of secondary effluent or diversions of effluent to the reclaimed system are partially offset when the effluent is supplied from the County's regional wastewater treatment plants at Ina and Roger Roads because this reduces the volume of effluent discharged to the river and incidentally recharged. Currently, a portion of the effluent that is not directly delivered in the AMA is discharged to the Santa Cruz River bed where around 90 percent of the discharged volume infiltrates back to the aquifer as incidental recharge. This incidental recharge is beneficial to the AMA water budget because it offsets groundwater use in calculations of groundwater overdraft.

11.4.2.3 Managed Recharge of Effluent

Effluent discharged from the Pima County regional wastewater treatment plants at Roger and Ina Roads is controlled by Pima County, the City of Tucson, and the United States Secretary of the Interior. The Secretary controls 28,200 acre-feet, while 90 percent of the remaining effluent is controlled by the City of Tucson and the other 10 percent is controlled by the County. By the year 2000, the City of Tucson and the United States Secretary of the Interior anticipate undertaking managed effluent recharge in the Santa Cruz River with their portions of the effluent that is being discharged from the Ina and Roger Road treatment

TABLE 11-7
MANAGED EFFLUENT RECHARGE PROJECTS
ASSUMPTIONS FOR WATER BUDGET SCENARIOS
TUCSON ACTIVE MANAGEMENT AREA

Factors	Projections (acre-feet)							
	1990	1995	2000	2005	2010	2015	2020	2025
Total Effluent Production at all Plants[1]	59,100	68,600	77,100	85,200	93,400	101,500	109,600	117,400
Effluent Production at Roger and Ina[2]	55,800	65,400	73,500	81,200	88,800	96,300	103,700	111,000
Secondary Effluent Diversions	5,100	3,000	4,500	4,700	4,900	5,100	5,300	5,500
Reclaimed System Diversions	5,000	6,900	9,000	9,600	10,000	10,400	10,100	9,800
Discharge to the Santa Cruz River	45,700	55,500	60,000	66,900	73,900	80,800	88,300	95,700
Total Managed Recharge Volume[3]	0	0	9,300	59,100	64,900	70,600	76,900	83,000
Cut to the Aquifer (50%)[4]	0	0	4,700	29,600	32,400	35,300	38,400	41,500
COT Credits used for Reclaimed[5]	0	0	1,900	6,100	8,500	11,400	12,800	13,900
SOI credits used by Municipal[6]	0	0	0	7,100	14,100	14,100	14,100	14,100
Annual Accrual of Unused Credits	0	0	2,700	16,300	9,900	9,800	11,600	13,500
Cumulative Accrual of Unused Credits	0	0	2,700	50,200	115,700	165,000	218,500	281,200
Incidental Recharge of Effluent[7]	41,200	50,000	45,700	1,200	1,700	2,200	2,700	3,100

[1] Includes production from all wastewater treatment plants in the AMA
[2] Includes production from Roger Road and Ina Road plants only
[3] Assumes the managed in-channel recharge volume for 2005 to 2025 is 90 percent of the City of Tucson's and the Secretary of the Interior's portions of the volume discharged to the Santa Cruz River
[4] Cut to the aquifer is equal to 50 percent of the in-channel recharge volume
[5] Effluent credits recovered by City of Tucson (COT) for delivery through the reclaimed system to meet balance of reclaimed demand
[6] Secretary of the Interior's (SOI) effluent credits recovered for use by municipal water providers (in place of recovery of CAP credits)
[7] Assumes 90 percent of effluent discharged to the river without a subsequent use reaches the aquifer as incidental recharge

plants. This will change the status of effluent discharged to the river to a managed water resource that is the source of accrued effluent recharge credits.

Managed effluent recharge is intended to be an interim measure until a regional effluent utilization approach is determined for this water. Other uses of this effluent could include increased direct use to meet agricultural, municipal, or industrial needs, or recharge in a constructed storage facility. Because the ultimate form effluent use will take is not known at this time, for purposes of the water budget managed effluent recharge is shown continuing through 2025 with the understanding that this could change in the future.

The volume of effluent available for managed effluent recharge depends on the volume discharged to the river. This volume in a given year is the volume produced at the Ina and Roger Road plants that remains after portions are diverted for use by turf-related facilities, agriculture, and the reclaimed system. Increased diversions from the regional plants for direct delivery would reduce discharges to the river and thus the effluent volume that could be used for managed and constructed recharge of effluent. Of the effluent discharged to the river, approximately 90 percent is assumed to be available for managed effluent recharge projects proposed by the City of Tucson and the Secretary of the Interior.

In a managed effluent recharge project, the effluent is still released to the river where it infiltrates to the aquifer, but it is accounted for differently by the Department once it is part of a managed recharge project. Credits are accrued for 50 percent of the volume that recharges the aquifer and the remaining 50 percent is deemed a "cut to the aquifer."

The 50 percent cut to the aquifer for managed effluent recharge represents a substantial reduction from the 90 percent of effluent that previously benefited the aquifer through incidental recharge. Effluent that would otherwise have been tallied as incidental recharge will become available for recovery by pumping groundwater. This could be detrimental to the AMA from a water management standpoint.

The City's current plans are to recover a portion of its effluent credits each year using wells placed adjacent to the river, and to use this recovered effluent to meet a portion of reclaimed water demand. The City's surplus recharged effluent will be accrued as long-term storage credits. The Secretary's effluent credits are intended to be sold and the proceeds of the sale used to purchase water supplies for the Tohono O'odham Nation. It is anticipated that the Secretary's credits will be purchased by municipal water providers to meet renewable use requirements of the AWS Program. Since the water would be put to potable use, it is anticipated that it will be recovered by pumping groundwater from other parts of the basin. The ability to recover credits purchased from the Secretary by pumping groundwater might be limited at the request of the Tohono O'odham to areas of the AMA that are not near the Reservation.

Projections related to managed effluent recharge and recovery are shown in Table 11-7. Total effluent production from all wastewater treatment plants in the AMA was 68,600 acre-feet in 1995 and is projected to reach 117,400 acre-feet by 2025. Of the total effluent produced at the Ina and Roger Road plants, 55,500 acre-feet were discharged to the river in 1995 and 95,700 acre-feet are projected to be discharged in 2025. It is anticipated that managed effluent recharge will commence by 2000.

The volume of managed effluent recharge is projected to be 9,300 acre-feet in 2000 based on an existing permit application submitted to the Department by the City of Tucson and the Secretary of the Interior for effluent in the Santa Cruz River between Roger and Ina Roads. The City and the Secretary have indicated that they will expand their managed recharge permit application to include the rest of the Santa Cruz River inside the AMA, so in the water budget the managed effluent recharge volume is projected to increase to around 59,100 acre-feet per year by 2005.

A portion of projected reclaimed system demand will be met using effluent diverted from the Roger Road treatment plant (some of which will then be stored in the Sweetwater recharge basins) and the remainder will be met using annual storage and recovery of managed effluent recharge credits accrued from effluent recharge (Table 11-7). For purposes of the water budget, it is assumed that the balance of the City's yearly unused managed effluent recharge credits will be accrued, resulting in a cumulative credit balance of 281,200 acre-feet in 2025 (Table 11-7). However, these credits could be recovered at any time by pumping groundwater from other locations in the AMA to serve municipal demand and help meet the City's assured water supply requirements. Managed in-channel effluent recharge credits cannot be considered when the Department evaluates whether a water provider has met the requirements necessary to obtain an assured water supply designation.

Because effluent infiltration has occurred historically and will predictably occur in the future, the cut to the aquifer for managed effluent recharge is added into the water budget in each year that managed recharge occurs, regardless of whether effluent credits are recovered in that year.

11.4.2.4 Constructed Recharge of Effluent

Constructed recharge of effluent takes place in basins or constructed in-channel features rather than in existing river channels that normally receive the water. A portion of the effluent diverted for use in the reclaimed system is currently recharged at basins constructed at the Sweetwater facility as part of City of Tucson's reclaimed system storage facilities. Effluent is recharged in the winter when demand for reclaimed water decreases and is recovered from this same area in the summer when water demand is high at turf-related facilities. This annual storage and recovery of effluent is accounted for in the reclaimed system diversions in Table 11-7. Annual storage and recovery of effluent stored in a constructed recharge project is considered direct use for purposes of the water budget. Effluent credits accrued through annual storage and recovery in basin recharge projects such as the Sweetwater facility can be used in the assured water supply determination.

Unlike managed in-channel recharge of effluent that has a 50 percent cut to the aquifer, long-term storage and recovery of effluent through constructed recharge projects does not have an associated cut to the aquifer. The volume of effluent recharge credits available for recovery is twice as large for effluent recharged through constructed projects as effluent recharged through managed in-channel projects. Recovery of stored effluent recharge credits can occur outside of the area where the effluent is recharged by pumping an equivalent volume of groundwater. Because effluent can be recovered from wells, the pumped water can be used to meet potable water needs at the same time it is accounted for as effluent. The implementation of this type of project could have the result of reducing the volume of water released to the river channel with corresponding implications for the health of riparian vegetation currently supported by effluent.

11.4.3 Central Arizona Project Water

CAP water can be used directly (except as limited by local ordinances) or through recharge and recovery projects. All CAP water used by the municipal sector, whether supplied though direct delivery or recovered storage, counts against municipal GPCD requirements. In addition, all CAP water use can be considered in obtaining an assured water supply. Because CAP is a renewable supply, CAP water use is considered consistent with achieving the safe-yield goal.

11.4.3.1 Direct Use of Central Arizona Project Water

CAP water is projected to be used directly for irrigation on the San Xavier District and Schuk Toak District by 2005 as discussed in section 11.3.1. CAP water can be delivered directly for potable use, but this has not occurred in the Tucson AMA since 1994. Direct delivery commenced in 1992 but was halted by the Mayor and Council of the City of Tucson in 1994 due to problems with the effects of direct delivery on piping and water quality in the Tucson Water distribution system. The Water Consumer Protection Act (WCPA) of 1995, a citizens' ballot initiative, prohibits direct delivery of CAP by the City of Tucson, as discussed in Chapter 8. The effect of the WCPA is to preclude direct delivery of CAP water unless CAP water can be treated to a quality that meets the initiative requirements or until other actions are taken that result in improvements in treatment plant technology and delivery infrastructure that are sufficient to secure public acceptance of CAP water as a potable supply. Due to these uncertainties regarding direct delivery of CAP water, direct delivery for use by the municipal sector is not projected to occur in the water budget scenarios. All future municipal use of CAP water is projected to occur through the recovery of recharge credits. Direct use of CAP water by the municipal sector in the amount of 100 acre-feet did occur in 1995 to maintain the Hayden-Udall water treatment plant.

11.4.3.2 CAP Recharge and Recovery

CAP recharge can occur in basins and channels, or through injection wells. Use of injection wells for CAP water recharge in the City of Tucson service area is effectively precluded by the WCPA, so basin and in-channel recharge are the current strategies being planned and implemented in the AMA. Recharge and recovery can occur on an annual storage and recovery basis or can be through long-term storage efforts. Credits are accrued by both of these methods; however, for annual storage and recovery projects, these credits must be recovered the same year the water is recharged. Once CAP water is recharged, the location from which it is "recovered" also affects its management characteristics. Water can be recovered within the Area of Impact (AOI) of water storage or outside the AOI. Criteria listed in Chapter 8 affect the ability of entities to recover water outside the AOI.

Estimates of CAP recharge capacity that could possibly be developed in the Tucson AMA are listed in Table 11-8. These estimates are based on the Regional Recharge Plan prepared by the Department in 1998 to summarize the results of the Institutional and Policy Advisory Group (IPAG) process and represent relatively optimistic estimates. The projected demand for recovery of CAP recharge credits by water providers is less than the possible developable recharge capacity, and is listed in Table 11-9.

While Table 11-8 shows possible developable CAP recharge capacity in the Tucson AMA, the actual volume of CAP recharge is likely to be less. The projected recovery of CAP recharge credits in the water budget shown in Table 11-9 is based on the more probable assumptions about potential demand for CAP recharge capacity that are specified for various water providers in the Regional Recharge Plan. The assumption used in the water budget for Tucson Water is that the volume of CAP recharge in a given year is equal to 80 percent of potable water demand in 2005 and continues at this rate through 2025. For other water providers designated under the AWS Program, it is assumed that CAP recharge is 50 percent of potable demand in 2000, increases to 75 percent of potable demand in 2005, and continues at 75 percent through 2025. This allows some time for recharge facilities to be constructed and begin operation. For subdivisions with Certificates of AWS (applied for after February 1995), it is assumed that the minimum CAP recharge level required by the CAGRD will occur each year. These estimates have been further reduced by the assumption that water providers will replace a portion of CAP credit recovery with recovery of an equal volume of effluent credits available from the Secretary of the Interior. Recovery of these effluent credits by the municipal sector is assumed to start at 7,050 acre-feet in 2005 and reach the full 14,100 acre-feet in 2010 (Table 11-9).

While, for purposes of the water budget, simplifying assumptions have been made about the volume of CAP that will be recharged and recovered, the actual volume water providers choose to recharge and recover could vary substantially from water budget projections and will depend on a number of factors including the recharge capacity of permitted facilities, water demand, physical availability of groundwater, the use of allowable mined groundwater, recovery of effluent recharge credits, and other factors. With the exception of AWBA CAP recharge (see section 11.4.3.3), no estimates have been made of the additional CAP water that might be recharged before 2025 without recovery of the associated credits by 2025. This is due to the high level of uncertainty about the number, size, location, and type of recharge facilities that could be built, and the optimistic assumptions already made that sufficient physical recharge capacity will exist to recharge the CAP necessary to meet projected CAP credit recovery demands. Additionally, if CAP water was eventually treated and served to meet potable demand, this would greatly affect future recharge and recovery decisions.

The total volume of CAP recharge entered in the budget for a given year is based on the total demand for CAP credit recovery assumed for that year in the water budget. There is no cut to the aquifer associated with annual storage and recovery projects so the entire volume of CAP water recharged on this basis can be recovered as credits. Long-term storage projects for CAP water, by statute, have a 5 percent cut to the aquifer associated with the recharge. The cut to the aquifer for long-term storage projects is added into the budget in the year the corresponding CAP credits are recovered.

Subdivisions that are members of the CAGRD can pump groundwater but must have a specified portion of this groundwater pumpage replenished by recharge of a comparable volume of renewable water. There is an associated cut to the aquifer for this replenishment. For purposes of the water budget, it is assumed that the renewable water source used is CAP water. The CAGRD has up to three years after the replenishment obligation is incurred to recharge the water, but, for purposes of the water budget, it is assumed this recharge occurs in the same year the replenishment obligation is incurred.

CAP water that is recharged but not recovered before 2025 does not appear in the water budget since it would result in an underestimate of groundwater mining. These credits will be recovered in the future and will appear in the water budget at the time they are recovered. The cut to the aquifer associated with these unrecovered credits will appear in the water budget in the year the credits are projected to be recovered.

TABLE 11-8
POSSIBLE DEVELOPABLE RECHARGE CAPACITY FOR CENTRAL ARIZONA PROJECT WATER
TUCSON ACTIVE MANAGEMENT AREA

Projected Facilities	Year						
	1995	2000	2005	2010	2015	2020	2025
Groundwater Savings Facilities and Projected Capacity in Acre-feet							
BKW Farms	4,200	16,000	16,000	13,000	9,000	6,000	3,000
Cortaro Marana Irrigation District	5,900	20,000	20,000	16,000	12,000	10,000	5,000
Kai at Picacho	0	11,000	11,000	8,000	6,000	6,000	4,000
BKW Farms at Mile Wide Road	0	600	600	600	600	600	600
Avra Valley Irrigation District	0	12,500	12,500	9,000	6,000	4,000	2,000
Farmers Investment Company	0	20,000	20,000	20,000	15,000	12,000	10,000
ASARCO Mission Complex	0	0	10,000	10,000	10,000	10,000	10,000
Basin and In-Channel Recharge Projects and Projected Capacity in Acre-feet							
Avra Valley	0	11,000	11,000	11,000	11,000	11,000	11,000
Lower Santa Cruz	0	13,000	30,000	30,000	30,000	15,000	10,000
Pima Mine Road	0	10,000	30,000	30,000	30,000	30,000	30,000
CAVSRP	0	15,000	30,000	30,000	60,000	60,000	60,000
Cañada Del Oro - Big Wash	0	0	30,000	30,000	30,000	30,000	30,000
Pantano, Rillito, and Tanque Verde	0	0	10,000	10,000	10,000	0	0
San Xavier District Spreading Basins	0	0	15,000	15,000	15,000	15,000	15,000
San Xavier District Arroyos	0	9,000	9,000	9,000	9,000	9,000	9,000
San Xavier District Santa Cruz River	0	7,000	7,000	7,000	7,000	7,000	7,000
Pascua Yaqui Basins	0	10,000	10,000	10,000	10,000	10,000	10,000
Total	**10,100**	**155,100**	**272,100**	**258,600**	**270,600**	**235,600**	**216,600**

CAVSRP = Central Avra Valley Storage and Recovery Project

11.4.3.3 Extinguishment of CAP Credits

The AWBA recharges CAP water for several purposes, two of which affect water budget assumptions. These purposes are to support achievement of AMA management goals and to provide recoverable water in times of shortage on the Colorado River (see Chapter 8). The AWBA will participate in some CAP recharge projects in the AMA. While it has not occurred yet, a portion of the CAP recharge credits accumulated by the AWBA through these recharge activities could be extinguished to support water management objectives in the AMA. Extinguishment of these credits would prevent them from being recovered in the future, so the CAP water recharged for eventual extinguishment would become a

TABLE 11-9
PROJECTED ANNUAL RECOVERY OF CENTRAL ARIZONA PROJECT AND EFFLUENT RECHARGE CREDITS TUCSON ACTIVE MANAGEMENT AREA

Factors	Year					
	2000	2005	2010	2015	2020	2025
BASE SCENARIO PROJECTIONS IN ACRE-FEET						
Total Renewable Credit Recovery Needed for AWS	**8,550**	**118,940**	**131,230**	**145,360**	**160,650**	**176,190**
Total Demand for Effluent Credits	0	7,050	14,100	14,100	14,100	14,100
Total Demand for CAP Credits	8,550	111,890	117,130	131,260	146,550	162,090
Total CAP Recharge Needed for AWS	**9,000**	**115,500**	**120,960**	**134,200**	**150,230**	**166,520**
Total Demand for CAP Credits	8,550	111,890	117,130	131,260	146,550	162,090
Designations[1]: CAP Credits Projected for ASR[2]	0	43,280	44,330	75,470	76,700	77,960
Designations[1]: CAP Credits Projected for LTS[3]	8,070	66,850	67,990	46,880	56,560	66,410
Certificates[4]: CAGRD Replenishment with CAP[5]	480	1,760	4,810	8,910	13,290	17,720
Total Cut to the Aquifer	450	3,610	3,830	2,940	3,680	4,430
Designations[1]: Cut to the Aquifer[3]	420	3,520	3,580	2,470	2,980	3,500
Certificates: Cut to the Aquifer[5]	30	90	250	470	700	930
TMP SCENARIO PROJECTIONS IN ACRE-FEET						
Total Renewable Credit Recovery Needed for AWS	**8,550**	**114,860**	**121,420**	**134,700**	**148,100**	**160,470**
Total Demand for Effluent Credits	0	7,050	14,100	14,100	14,100	14,100
Total Demand for CAP Credits	8,550	107,810	107,320	120,600	134,000	146,370
Total CAP Recharge Needed for AWS	**9,000**	**111,230**	**110,690**	**123,040**	**137,090**	**150,060**
Total Demand for CAP Credits	8,550	107,810	107,320	120,600	134,000	146,370
Designations[1]: Credits Projected for ASR[2]	0	42,820	43,220	74,260	75,280	76,180
Designations[1]: Credits Projected for LTS[3]	8,070	63,230	59,290	37,430	45,430	52,470
Certificates[4]: CAGRD Replenishment[5]	480	1,760	4,810	8,910	13,290	17,720
Total Cut to the Aquifer	450	3,420	3,370	2,440	3,090	3,690
Designations[1]: Cut to the Aquifer[3]	420	3,330	3,120	1,970	2,390	2,760
Certificates[4]: Cut to the Aquifer[5]	30	90	250	470	700	930

CAP = Central Arizona Project; AWS = Assured Water Supply; CAGRD = Central Arizona Groundwater Replenishment District

[1] Service areas with Assured Water Supply Designations: Tucson Water, Oro Valley, Vail, Marana, Metropolitan Domestic Water Improvement District, Spanish Trail

[2] Annual storage and recovery (ASR) does not have an associated cut to the aquifer

[3] Long-term storage and recovery (LTS) has an associated 5 percent cut to the aquifer

[4] Includes existing and projected subdivisions with Certificates of Assured Water Supply

[5] The CAGRD can recharge CAP up to three years after a CAGRD member pumps groundwater that has an associated replenishment obligation. There is a 5 percent associated cut to the aquifer. For purposes of the water budget, CAP is assumed to be recharged the same year the replenishment obligation is incurred.

permanent addition to the groundwater supply in the aquifer. The volume of CAP recharge credits that could be extinguished by the AWBA has been projected based on estimated annual groundwater withdrawal fees that will be collected and used to purchase and recharge excess CAP water before 2017, the current legislative date for cessation of AWBA activities. Extinguishment of credits is projected to occur as shown in Table 11-10. On a cumulative basis, it would be possible for the AWBA to extinguish 156,650 acre-feet of CAP recharge credits in this AMA by 2017.

TABLE 11-10
PROJECTED EXTINGUISHMENT OF CENTRAL ARIZONA PROJECT RECHARGE CREDITS BY ARIZONA WATER BANKING AUTHORITY TUCSON ACTIVE MANAGEMENT AREA

Scenario	Extinguished CAP Credits (acre-feet)						
	1995	2000	2005	2010	2015	2020	2025
Base Scenario	0	0	0	0	0	0	0
TMP Scenario	0	11,700	8,400	7,900	7,600	0	0

CAP = Central Arizona Project
TMP = Third Management Plan

11.5 RESULTS OF WATER BUDGET ANALYSES

Projected water budget results through 2025 have been calculated for the Base and TMP Scenarios. These scenarios indicate the amount of water conservation and/or supply augmentation needed to offset future groundwater overdraft. The water budget scenarios do not reflect water savings that may result from conservation requirements in the Fourth and Fifth Management Plans. Results of the water budget calculations are tabulated and described in the following sections (Tables 11-11 and 11-12). Analysis and discussion of these results are presented in section 11.6.

11.5.1 Base Scenario

In the Base Scenario, it is assumed that the rate at which water is used by the municipal, industrial, and agricultural sectors in 1995 continues through 2025 (Table 11-11). Cumulative groundwater use by these sectors is shown in Table 11-13. The size of the municipal sector is projected to grow substantially during this period, the size of the industrial sector is expected to grow slightly, and the agricultural sector is projected to decrease in size by 2025.

Total water demand in the Base Scenario in 2025 is projected to be 416,700 acre-feet. Total municipal demand increases from 155,500 acre-feet in 1995 to 267,100 acre-feet in 2025 with a total population of around 1,266,500 in 2025. Recovery of CAP recharge credits by the municipal sector did not occur in 1995 but is projected to reach 8,500 acre-feet in 2000 and 162,100 acre-feet in 2025. This large increase is due to the phasing in of the AWS Program requirements for use of renewable supplies, which begin in 1999 for most large providers and begin in 2001 for Tucson Water. Groundwater use by the municipal sector is projected to be 67,300 acre-feet in 2025, a decrease from 147,700 acre-feet of groundwater use in 1995.

CAP water use for Indian agriculture, overall reduction in agricultural demand, and some effluent use by this sector results in a decrease in groundwater use for agriculture from 96,200 acre-feet in 1995 to 51,200 acre-feet in 2025. Total demand in the agricultural sector was 98,000 acre-feet in 1995 and is projected to decrease to 70,000 acre-feet in 2025. An increase in Indian irrigation is included in this total. Indian demand will be met with 15,800 acre-feet of CAP water by 2025.

TABLE 11-11
BASE SCENARIO: PROJECTED FUTURE CONDITIONS ASSUMING 1995 CONDITIONS CONTINUE THROUGH 2025, TUCSON ACTIVE MANAGEMENT AREA

Sector	1990	1995	2000	2005	2010	2015	2020	2025
Projected AMA Population	655,000	768,000	838,300	920,900	1,005,300	1,092,200	1,179,200	1,266,500
Projected Irrigation Acres	40,000	36,100	35,320	35,750	33,900	30,400	26,400	21,400
IGFRs	40,000	36,100	35,100	33,600	30,600	27,100	23,100	18,100
Indian Irrigation	0	0	220	2,150	3,300	3,300	3,300	3,300
Municipal Sector								
Total Demand	130,100	155,500	172,900	193,500	212,100	231,900	249,800	267,100
Non-Indian[1]	130,000	155,400	172,800	193,400	212,000	231,800	249,600	266,900
Indian[2]	100	100	100	100	100	100	200	200
Total Supply	130,100	155,500	172,900	193,500	212,100	231,900	249,800	267,100
CAP	0	100[3]	8,500[4]	111,900[4]	117,100	131,300	146,600	162,100
Effluent[5]	6,300	7,700	11,600	23,400	32,900	36,000	37,100	37,700
Groundwater	123,800	147,700	152,800	58,200	62,100	64,600	66,100	67,300
Agricultural Sector								
Total Demand	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
Non-Indian[1]	93,800	98,000	103,600	107,400	91,700	81,200	69,200	54,200
Indian[2]	0	0	1,100	10,300	15,800	15,800	15,800	15,800
Total Supply	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
CAP	0	0	0	10,400	15,800	15,800	15,800	15,800
Effluent	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Groundwater	89,800	96,200	101,700	104,300	88,700	78,200	66,200	51,200
Industrial Sector								
Total Demand	48,800	60,200	71,000	72,100	73,800	73,500	74,700	75,900
Total Supply	48,800	60,200	71,000	72,100	73,800	73,500	74,700	75,900
CAP	0	0	0	0	0	0	0	0
Effluent	800	800	1,300	1,700	2,900	3,600	4,200	4,700
Groundwater	48,000	59,400	69,700	70,400	70,900	69,900	70,500	71,200
Other Demands								
Demand: Evapotranspiration	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Supply: Groundwater	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Total Demand	276,400	317,400	352,300	387,000	397,100	406,100	413,200	416,700
Total Groundwater Use	265,300	307,000	327,900	236,600	225,400	216,400	206,500	193,400
(Less) Net natural recharge[6]	60,800	60,800	60,800	60,800	60,800	60,800	60,800	60,800
(Less) Incidental recharge[7]	70,300	82,300	80,800	39,900	35,600	35,200	34,400	33,300
(Less) Cuts to aquifer	0	0	5,100	33,200	36,300	38,200	42,100	46,000
(Less) Extinguished credits[8]	0	0	0	0	0	0	0	0
Actual Overdraft	134,200	163,900	181,200	102,700	92,700	82,200	69,200	53,300
(Less) Remediation water	0	0	8,400	7,000	6,500	6,500	6,500	6,500
(Less) Allowable groundwater	0	0	10,000	33,400	37,000	39,200	40,300	41,100
Accounting Overdraft	134,200	163,900	162,800	62,300	49,200	36,500	22,400	5,700

NOTE: all units are acre-feet unless otherwise noted.
AMA = Active Management Area; IGFRs = Irrigation Grandfathered Rights; CAP = Central Arizona Project

[1] Non-Indian demand indicates demand for uses off Indian Reservation lands. For the municipal sector, this demand includes exempt well use. For the agricultural sector, this demand includes canal losses and irrigation use by exempt small rights.
[2] Indian demand includes San Xavier and Schuk Toak Districts of the Tohono O'odham Reservation within AMA boundaries
[3] 100 acre-feet of CAP water used for treatment plant maintenance
[4] Renewable supply use by Tucson Water commences in 2001
[5] Includes secondary effluent, reclaimed system effluent, and effluent credits purchased from the Secretary of the Interior
[6] Net Natural Recharge is composed of mountain front recharge, stream channel recharge, and groundwater inflow less outflow.
[7] Incidental recharge decreases between 2000 and 2005 when managed in-channel effluent recharge increases substantially
[8] Extinguishment of Arizona Water Banking Authority CAP recharge credits is not assumed to take place in the Base Scenario

TABLE 11-12
THIRD MANAGEMENT PLAN SCENARIO: PROJECTED FUTURE CONDITIONS ASSUMING THIRD MANAGEMENT PLAN CONSERVATION GOALS ARE ACHIEVED BY 2010 AND CONTINUE THROUGH 2025, TUCSON ACTIVE MANAGEMENT AREA

Sector	1990	1995	2000	2005	2010	2015	2020	2025
Projected AMA Population	655,000	768,000	838,300	920,900	1,005,300	1,092,200	1,179,200	1,266,500
Projected Irrigation Acres	40,000	36,100	35,320	35,750	33,900	30,400	26,400	21,400
IGFRs	40,000	36,100	35,100	33,600	30,600	27,100	23,100	18,100
Indian Irrigation	0	0	220	2,150	3,300	3,300	3,300	3,300
Municipal Sector								
Total Demand	130,100	155,500	172,900	188,300	199,800	218,500	234,000	247,300
Non-Indian[1]	130,000	155,400	172,800	188,200	199,700	218,400	233,800	247,100
Indian[2]	100	100	100	100	100	100	200	200
Total Supply	130,100	155,500	172,900	188,300	199,800	218,500	234,000	247,300
CAP	0	100[3]	8,500[4]	107,800[4]	107,300	120,600	134,000	146,400
Effluent[5]	6,300	7,700	11,600	23,400	32,900	36,000	37,100	37,700
Groundwater	123,800	147,700	152,800	57,100	59,600	61,900	62,900	63,200
Agricultural Sector								
Total Demand	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
Non-Indian[1]	93,800	98,000	103,600	107,400	91,700	81,200	69,200	54,200
Indian[2]	0	0	1,100	10,300	15,800	15,800	15,800	15,800
Total Supply	93,800	98,000	104,700	117,700	107,500	97,000	85,000	70,000
CAP	0	0	0	10,400	15,800	15,800	15,800	15,800
Effluent	4,000	1,800	3,000	3,000	3,000	3,000	3,000	3,000
Groundwater	89,800	96,200	101,700	104,300	88,700	78,200	66,200	51,200
Industrial Sector								
Total Demand	48,800	60,200	71,000	72,100	73,300	73,000	74,200	75,400
Total Supply	48,800	60,200	71,000	72,100	73,300	73,000	74,200	75,400
CAP	0	0	0	0	0	0	0	0
Effluent	800	800	1,300	1,700	2,900	3,600	4,200	4,700
Groundwater	48,000	59,400	69,700	70,400	70,400	69,400	70,000	70,700
Other Demands								
Demand: Evapotranspiration	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Supply: Groundwater	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Total Demand	276,400	317,400	352,300	381,800	384,300	392,200	396,900	396,400
Total Groundwater Use	265,300	307,000	327,900	235,500	222,400	213,200	202,800	188,800
(Less) Net natural recharge[6]	60,800	60,800	60,800	60,800	60,800	60,800	60,800	60,800
(Less) Incidental recharge[7]	70,300	82,300	80,800	39,700	35,000	34,500	33,700	32,400
(Less) Cuts to aquifer	0	0	5,100	33,000	35,800	37,700	41,500	45,200
(Less) Extinguished credits[8]	0	0	11,700	8,400	7,900	7,600	0	0
Actual Overdraft	134,200	163,900	169,500	93,600	82,900	72,600	66,800	50,400
(Less) Remediation water	0	0	8,400	7,000	6,500	6,500	6,500	6,500
(Less) Allowable groundwater	0	0	10,000	32,400	34,500	36,500	37,000	37,000
Accounting Overdraft	134,200	163,900	151,100	54,200	41,900	29,600	23,300	6,900

NOTE: all units are acre-feet unless otherwise noted.
AMA = Active Management Area; IGFRs = Irrigation Grandfathered Rights;
1 Non-Indian demand indicates demand for uses off Indian Reservation lands. For the municipal sector, this demand includes exempt well use. For the agricultural sector, this demand includes canal losses and irrigation use by exempt small rights.
2 Indian demand includes San Xavier and Schuk Toak Districts of the Tohono O'odham Reservation within AMA boundaries
3 100 acre-feet of CAP water used for treatment plant maintenance
4 Renewable supply use by Tucson Water commences in 2001
5 Includes secondary effluent, reclaimed system effluent, and effluent credits purchased from the Secretary of the Interior
6 Net Natural Recharge is composed of mountain front recharge, stream channel recharge, and groundwater inflow less outflow.
7 Incidental recharge decreases between 2000 and 2005 when managed in-channel effluent recharge increases substantially
8 Extinguishment of Arizona Water Banking Authority CAP recharge credits is assumed to take place only in the TMP Scenario

Industrial demand is projected to continue to grow slightly during this period with effluent use replacing some groundwater use. Groundwater use is projected to be 71,200 acre-feet in 2025 for the industrial sector, an increase from 59,400 acre-feet in 1995. Total demand by 2025 is projected to be 75,900 acre-feet for the industrial sector, an increase from 60,200 acre-feet in 1995.

In the Base Scenario, groundwater accounts for 193,400 acre-feet of water use in 2025 for all sectors combined. This total volume is offset by a combined total of 140,100 acre-feet of net natural recharge, incidental recharge, and cuts to the aquifer from recharge projects to yield an actual overdraft of 53,300 acre-feet. The subtraction of allowable mined remediation water and allowable mined groundwater through the AWS Program reduces the actual groundwater overdraft to 5,700 acre-feet. For accounting purposes, the use of allowable mined groundwater is considered acceptable in the context of meeting the AMA's goal. However, in actuality groundwater overdraft continues and this issue may need to be revisited. Cumulative actual and accounting groundwater overdraft between 1995 and 2025 is shown in Table 11-13.

TABLE 11-13
BASE AND TMP SCENARIOS CUMULATIVE WATER BUDGET FACTORS
TUCSON ACTIVE MANAGEMENT AREA

BASE SCENARIO	
Cumulative Municipal Groundwater use 1995 to 2025	2,704,200 acre-feet
Cumulative Agricultural Groundwater use 1995 to 2025	2,660,200 acre-feet
Cumulative Industrial Groundwater use 1995 to 2025	2,142,900 acre-feet
Cumulative Municipal Remedial Groundwater Use 2000 to 2025	178,150 acre-feet
Cumulative Municipal Allowable Groundwater Use 2000 to 2025	887,250 acre-feet
Cumulative Arizona Water Banking Authority Extinguished Credits 2000 to 2017	0 acre-feet
Cumulative Actual Overdraft 1995 to 2025	3,346,900 acre-feet
Cumulative Accounting Overdraft 1995 to 2025	2,253,900 acre-feet
TMP SCENARIO	
Cumulative Municipal Groundwater use 1995 to 2025	2,646,450 acre-feet
Cumulative Agricultural Groundwater use 1995 to 2025	2,660,200 acre-feet
Cumulative Industrial Groundwater use 1995 to 2025	2,134,150 acre-feet
Cumulative Municipal Remedial Groundwater Use 2000 to 2025	178,150 acre-feet
Cumulative Municipal Allowable Groundwater Use 2000 to 2025	829,500 acre-feet
Cumulative Arizona Water Banking Authority Extinguished Credits 2000 to 2017	156,650 acre-feet
Cumulative Actual Overdraft 1995 to 2025	3,126,650 acre-feet
Cumulative Accounting Overdraft 1995 to 2025	2,091,400 acre-feet

11.5.2 Third Management Plan Scenario

The TMP Scenario assumes that Third Management Plan conservation goals are met by 2010 and this level of conservation continues through 2025 (Table 11-12). Cumulative groundwater use by these sectors is shown in Table 11-13. Water supplies projected to meet municipal, agricultural and industrial water demands are shown in Figure 11-2. Specific changes made between the Base Scenario and the TMP

Scenario to address conservation savings include a decrease in average municipal GPCD from 172 in 1995 to 158 in 2025 and a 1 percent savings in industrial water use for mines and sand and gravel facilities. Total demand for all sectors in the TMP Scenario is projected to be 396,400 acre-feet in 2025.

Total demand for the municipal sector is projected at 247,300 acre-feet in 2025, with estimated conservation savings of 19,800 acre-feet in the TMP Scenario compared to the Base Scenario. Groundwater demand by the municipal sector is projected to be 63,200 acre-feet in 2025. Agricultural demand is 70,000 acre-feet in both the Base and TMP Scenarios with groundwater demand in 2025 and cumulative groundwater demand remaining the same in both water budget scenarios. Industrial demand is projected at 75,400 acre-feet in 2025 in the TMP Scenario indicating conservation savings of around 500 acre-feet over the Base Scenario. Groundwater demand is projected to total 70,700 acre-feet for industrial users in 2025. Differences in sector demand between the Base and TMP Scenarios are shown in Figure 11-3 (Note: Base and TMP Scenario industrial demand differences do not show on this graph because of their relatively small magnitude).

Third Management Plan conservation requirements are projected to decrease municipal and industrial groundwater demand by a cumulative total of 57,750 acre-feet and 8,750 acre-feet, respectively, between 1995 and 2025 (Table 11-13).

In the TMP Scenario, groundwater accounts for 188,800 acre-feet of the water use in 2025 with around 138,400 acre-feet of this groundwater use offset by net natural recharge, incidental recharge, and cuts to the aquifer from recharge projects to yield an actual overdraft of 50,400 acre-feet. The subtraction of remediation groundwater and allowable mined groundwater through the AWS Program reduces the actual groundwater overdraft to an accounting-based overdraft of 6,900 acre-feet in 2025. While actual overdraft in the TMP Scenario is 2,900 acre-feet less than that in the Base Scenario, the accounting overdraft is 1,200 acre-feet higher in the TMP, reflecting the effects of reduced use of allowable mined groundwater due to lower overall municipal demand. Again, for accounting purposes, the use of allowable mined groundwater is considered acceptable in the context of meeting the AMA's goal. However, in actuality groundwater overdraft continues and this issue may need to be revisited. Extinguishment of CAP credits by the AWBA affects overdraft only in the water budget years of 2000 to 2015, therefore overdraft in 2025 is not reduced by this factor.

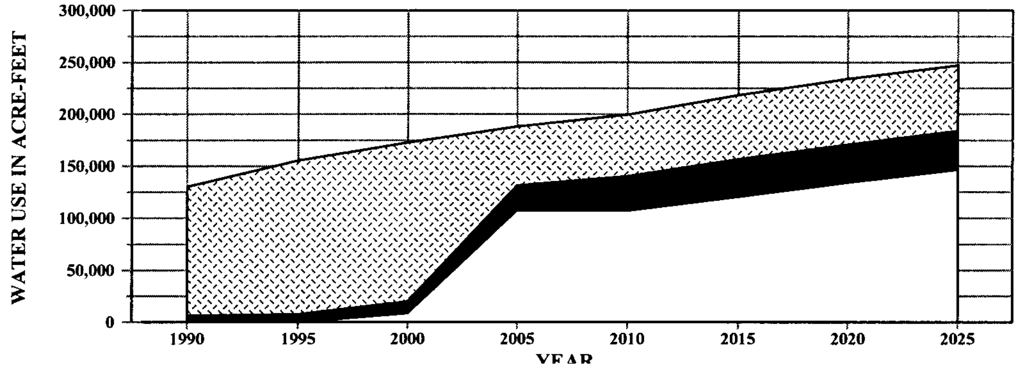
Cumulative actual and accounting groundwater overdraft between 1995 and 2025 is shown in Table 11-13. A comparison of the actual cumulative groundwater overdraft of 3,346,900 in the Base Scenario, and 3,126,650 acre-feet in the TMP Scenarios indicates a cumulative groundwater savings of around 220,250 acre-feet during the time period of 1995 to 2025. Groundwater reserves in the Tucson AMA in 1995 were estimated at 63 million acre-feet to a depth of 1,200 feet below land surface. Groundwater overdraft of around 3.1 million acre-feet by 2025 would reduce the volume of groundwater in storage by approximately 5 percent. It is important to note that although groundwater storage is estimated to a depth of 1,200 feet below land surface, it is not feasible to pump groundwater from this depth due to land subsidence, water quality deterioration, loss of well productivity, and increased pumping costs. With the large CAP allocations available for use in the Tucson AMA, the vast majority of this change in groundwater storage could be prevented by full utilization of this renewable water supply.

11.6 ANALYSIS AND DISCUSSION

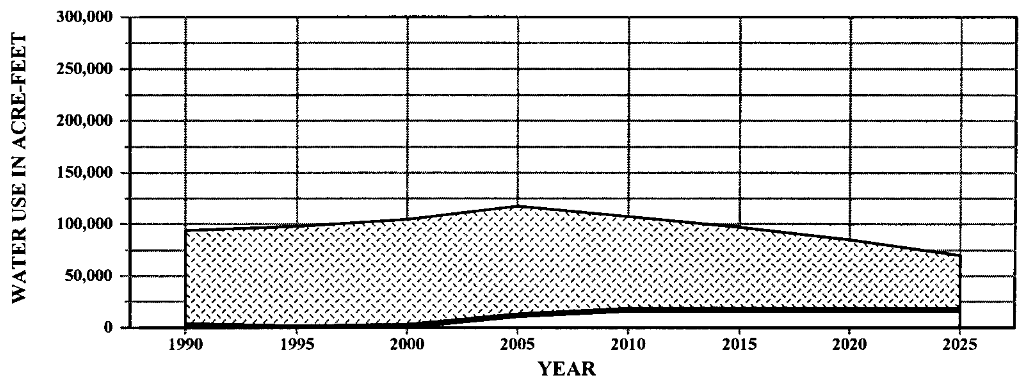
The water budget can be evaluated relative to past projections, its sensitivity to changes in budget variables, and its context in the span of the next century. These topics are discussed in the following sections.

FIGURE 11-2
THIRD MANAGEMENT PLAN SCENARIO
TUCSON ACTIVE MANAGEMENT AREA

MUNICIPAL WATER SOURCES



AGRICULTURAL WATER SOURCES



INDUSTRIAL WATER SOURCES

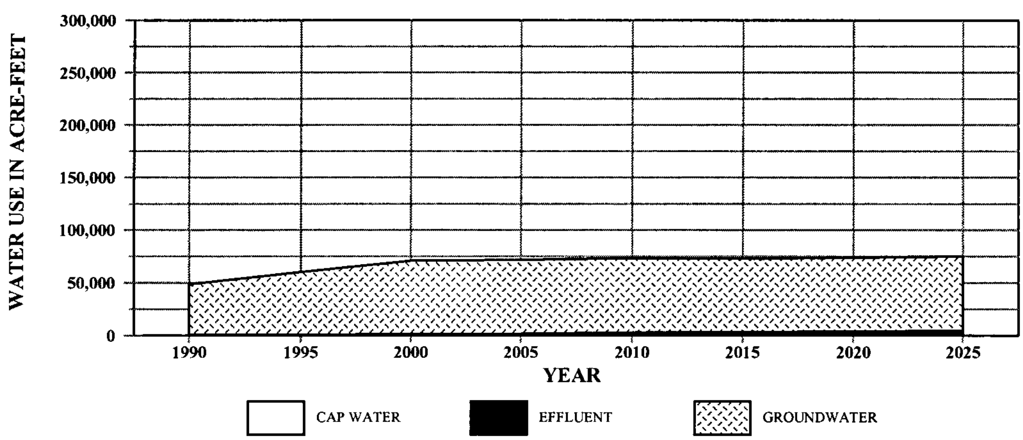
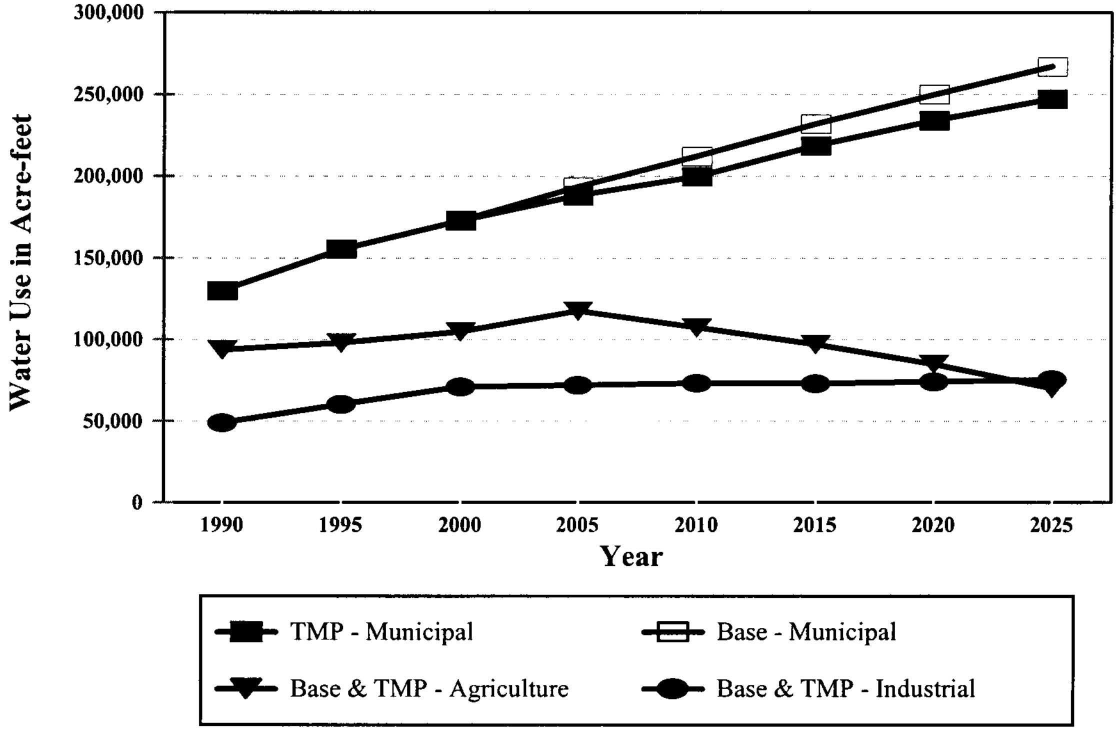


FIGURE 11-3
COMPARISON OF BASE SCENARIO AND
THIRD MANAGEMENT PLAN SCENARIO DEMAND
TUCSON ACTIVE MANAGEMENT AREA



11.6.1 Comparison to Previous Water Budget Analyses

Water use scenarios prepared for the Second Management Plan included the portion of the Upper Santa Cruz Valley Subbasin located between the United States/Mexico border and approximately the Pima/Santa Cruz County line. This area has since become the Santa Cruz AMA and is no longer included in water budget estimates for the Tucson AMA. Overdraft, water demand, and water supply numbers from the Second Management Plan are not strictly comparable to Third Management Plan numbers because of this change in geographic extent. Nevertheless, it is useful to compare selected assumptions to show their evolution from the Second Management Plan to the Third Management Plan.

Municipal, industrial, and agricultural sector water use projections have been updated to reflect current conditions and Third Management Plan conservation requirements. Population projections have been revised to an estimated 1,266,500 inhabitants in 2025 based on updated population data and growth projections. The Second Management Plan projected a population of 1,693,000 in 2025.

It was anticipated in the Second Management Plan water budget that 166,000 acre-feet of CAP water would be delivered for direct use by the municipal sector in 1995. Due to problems with direct delivery and the resultant shut down of the CAP water treatment plant, CAP water use in 1995 was only around

10,000 acre-feet and was almost all in the form of recharge through groundwater savings facilities; the associated recharge credits were not recovered in 1995. Only the 100 acre-feet of CAP water directly used to maintain the Hayden-Udall treatment plant is shown in the water budget for 1995. In the Third Management Plan, it is assumed that municipal sector use of CAP water takes the form of recovery of CAP recharge credits rather than direct delivery. Less acreage is projected to be used for Indian agriculture than the 11,300 acres projected in the Second Management Plan. The Third Management Plan projection is for 3,300 acres of irrigated agriculture to be developed based on current estimates of potential CAP utilization on Indian lands.

In the Second Management Plan document, it was expected that 50 percent of effluent would be used directly or artificially recharged by 2000, in part based on plans for effluent utilization by the City of Nogales, which was then part of the Tucson AMA. In the Third Management Plan, effluent use in the form of secondary effluent use and reclaimed system use is projected to reach around 31,300 acre-feet by 2025. An additional 14,100 acre-feet of long-term storage credits from managed effluent recharge projects are also projected to be used in 2025. This total use of 45,400 acre-feet represents around 40 percent of the 117,400 acre-feet of total effluent production.

Second Management Plan assumptions that storm water recharge, watershed management, and weather modification would supply 10,000 acre-feet per year beginning in 2000 have not been carried over into the Third Management Plan water budgets. This change reflects the increasing focus on using currently available renewable supplies rather than creating new water sources through technological efforts.

The Third Management Plan estimate of net natural recharge is 60,800 acre-feet per year, compared to 62,000 acre-feet per year in the Second Management Plan. This change reflects revisions based on recent computer modeling results and removal of net natural recharge volumes for what is now the Santa Cruz AMA.

Several incidental recharge factors have been revised since the Second Management Plan. Effluent discharged into the Santa Cruz River bed is now estimated to have an incidental recharge factor of 90 percent rather than the 40 percent factor used in the Second Management Plan. A 4 percent incidental recharge factor has been added for municipal sector use based on assumptions about the level of municipal incidental recharge used in the AWS Program and the municipal Non-Per Capita Conservation Program. Incidental recharge from the metal mines has been revised from 25 percent of demand in the Second Management Plan to 12 percent in the Third Management Plan based on a recent analysis of water use at AMA metal mines. A 12 percent incidental recharge factor has been added to address other large industrial water users as well.

CAP recharge projects in which long-term storage credits are accrued or CAGRD replenishment occurs include a 5 percent cut to the aquifer. Managed effluent recharge using the Santa Cruz River channel results in a 50 percent cut to the aquifer. These cuts to the aquifer offset total groundwater use in the calculation of groundwater overdraft. Additional factors added to the Third Management Plan water budgets affect overdraft calculations. These include extinguishment of AWBA CAP recharge credits, use of remediation water, and use of allowable mined groundwater under the AWS Rules.

11.6.2 Sensitivity Analyses

Sensitivity analyses were performed on selected water budget factors to determine the hypothetical impacts of these factors on sector demand, cumulative groundwater use, actual overdraft, and accounting overdraft. As discussed in the following sections, the Department's control over these factors varies from having a major impact to having no impact at all.

Two types of variations were evaluated. In the first approach, sector demand and supply factors were increased or decreased by a consistent 10 percent, one factor at a time. In the second approach, selected factors were changed one at a time by a variety of amounts based on hypothetical future changes in demand and supply. Each variation can affect other calculations in the budget such as incidental recharge. Both sensitivity analysis approaches illustrate hypothetical ranges that could occur in the future and do not constitute projections. The TMP Scenario was used as the starting point for all sensitivity analysis calculations.

11.6.2.1 Variations of 10 Percent in Sector Variables

Municipal, industrial, and agricultural factors were adjusted one at a time to 110 percent of their current projections and to 90 percent of their current projections in order to determine the relative impact of these factors on 2025 sector demand, cumulative groundwater use for that sector between 1995 and 2025, actual groundwater overdraft in 2025 and accounting overdraft in 2025. These are listed below and include both demand and supply factors. Results of these analyses are shown in Table 11-14.

- Municipal GPCD water use rates
- Municipal demand for CAP recharge credits
- Irrigation efficiency
- Agricultural effluent use
- Metal mining water demand
- Industrial effluent use

The sensitivity analysis results illustrate the complex interaction between water budget variables. For example, changes in municipal GPCD have a large potential impact on municipal sector demand in 2025 and cumulative municipal groundwater demand from 1995 to 2025 (Table 11-14). In terms of the demand factors, this is consistent with the growing dominance of municipal use in the water budget. In 1995, the municipal sector constituted about 50 percent of water use in the AMA. In 2025, it is projected to increase to around 60 percent of AMA water use. Variations in GPCD had a relatively small impact on actual and accounting overdraft in 2025. The overdraft volumes illustrate the effect of the AWS Rules, which require the municipal sector to meet its growing demand with renewable supplies. This buffers the effects of changes in municipal demand on overdraft. However, neither projections nor sensitivity analyses cover all possible future scenarios, nor do they extend past 2025. If, due to large increases in population, large increases in per capita use, reduced availability of renewable supplies, and/or depletion of allowable mined groundwater reserves, municipal demand becomes greater than the available CAP, effluent, and allowable mined groundwater supplies, municipal demand will have a substantial effect on overdraft. Reductions in municipal demand now reduce the rate at which allowable groundwater reserves are used, retaining them for future use.

If use of CAP recharge credits increased by 10 percent, municipal demand would not change but actual groundwater overdraft and cumulative municipal groundwater use could be reduced substantially. Accounting overdraft would change only slightly, since increased CAP use would basically replace allowable groundwater use, with an associated small change in the CAP cut to the aquifer. The need for municipal recovery of CAP recharge credits is a function of requirements of the AWS Rules, but the time table for recovery of these credits is flexible for water providers. Complete conversion to renewable supplies by 2025 is not within regulatory control.

TABLE 11-14
RESULTS OF SENSITIVITY ANALYSIS OF 10 PERCENT VARIATIONS ON OVERDRAFT IN 2025
TUCSON ACTIVE MANAGEMENT AREA

Variable Values in 2025	2025 Sector Demand (AF)	Change in Sector Demand (AF)	1995 - 2025 Cum Grw use by Sector (AF)	Change in Cum Grw Use (AF)	2025 Actual Overdraft (AF)	Change in Actual Overdraft (AF)	2025 Accounting Overdraft (AF)	Change in Accounting Overdraft (AF)
GPCD Variations								
142 GPCD (-10%)	225,000	-22,300	2,479,700	-166,750	47,600	-2,800	8,700	1,800
158 GPCD (TMP)	247,300	0	2,646,450	0	50,400	0	6,900	0
174 GPCD (+10%)	269,700	22,400	2,811,200	164,750	53,400	3,000	5,300	-1,600
CAP Credit Recovery								
161,040 AF (+10%)	247,300	0	2,360,950	-285,500	35,500	-14,900	6,200	-700
146,400 AF (TMP)	247,300	0	2,646,450	0	50,400	0	6,900	0
131,760 AF (-10%)	247,300	0	2,931,200	284,750	65,300	14,900	7,500	600
Irrigation Efficiency								
88% (+10%)	65,100	-4,900	2,442,450	-217,750	46,200	-4,200	2,700	-4,200
80% (TMP)	70,000	0	2,660,200	0	50,400	0	6,900	0
72% (-10%)	76,000	6,000	2,927,200	267,000	55,400	5,000	11,900	5,000
Agricultural Effluent								
3,300 AF (+10%)	70,000	0	2,651,950	-8,250	50,300	-100	6,800	-100
3,000 AF (TMP)	70,000	0	2,660,200	0	50,400	0	6,900	0
2,700 AF (-10%)	70,000	0	2,668,450	8,250	50,400	0	6,900	0
Mining Demand								
42,300 AF (-10%)	70,700	-4,700	2,004,400	-129,750	46,300	-4,100	2,800	-4,100
47,000 AF (TMP)	75,400	0	2,134,150	0	50,400	0	6,900	0
51,700 AF (+10%)	80,100	4,700	2,263,900	129,750	54,500	4,100	11,000	4,100
Industrial Effluent								
5,200 AF (+10%)	75,400	0	2,125,900	-8,250	50,100	-300	6,600	-300
4,700 AF (TMP)	75,400	0	2,134,150	0	50,400	0	6,900	0
4,300 AF (-10%)	75,400	0	2,141,900	7,750	50,800	400	7,300	400

Cum Grw = Cumulative Groundwater
AF = acre-feet
GPCD = gallons per capita per day
TMP = Third Management Plan
CAP= Central Arizona Project

In 2025, agricultural and industrial uses are each projected to constitute around 20 percent of AMA demand. Increases or decreases in variables affecting demand in these sectors result in a smaller change in water volume than those experienced in the municipal sector. However, in contrast to the municipal sector, changes in agricultural and industrial demand have a relatively direct effect on actual overdraft, accounting overdraft, and cumulative groundwater use since groundwater is the predominant supply for these sectors.

Changes of 10 percent in agricultural and industrial effluent use have no impact on overall sector demand, and only small impacts on cumulative groundwater use by these sectors, since a 10 percent change equates to less than 500 acre-feet difference in effluent use each year. Actual and accounting overdraft change very little in the case of shifts in agricultural effluent use because this effluent is supplied by Pima County and would be discharged to the Santa Cruz River if it were not diverted for agricultural use, where the majority would infiltrate as incidental recharge. Actual and accounting overdraft change slightly with changes in industrial effluent demand because it is assumed that most of this effluent would otherwise become part of the managed effluent recharge project, so only 50 percent of it would infiltrate as incidental recharge if it were not diverted for industrial use.

11.6.2.2 Hypothetical Variations in Selected Factors Affecting Groundwater Overdraft

Several additional factors were evaluated to determine the effect on water use of hypothetical major shifts in variables (Table 11-15). The following supply and demand factors were evaluated:

- Comparison of TMP Scenario population estimates to a hypothetical population of 1,000,000 by 2025.
- Comparison of TMP Scenario CAP demand estimates to CAP demand if 100 percent of potable demand was met by recovery of CAP recharge credits.
- Comparison of TMP Scenario for managed effluent recharge to hypothetical effects of using this same volume of water in constructed effluent recharge projects or of not conducting either managed or constructed effluent recharge.
- Comparison of TMP Scenario reductions in IGFRs of 50 percent to a hypothetical 75 percent reduction in IGFRs.
- Comparison of TMP Scenario agricultural effluent use projections to the hypothetical effects of agricultural use of 28,200 acre-feet of effluent available from the United States Secretary of the Interior in place of groundwater.
- Comparison of TMP Scenario metal mining demand estimates to the lower mining demand level experienced in the 1980s.
- Comparison of TMP Scenario metal mining demand met entirely by groundwater to hypothetical direct use of 10,000 acre-feet of CAP water to meet mining demand.

Since these changes are hypothetical and not related to one another, they are not strictly comparable, but they do illustrate the impact of several key factors on water use. Population projections change when new data indicate shifts in growth rates. If population reached only 1,000,000 people in 2025, municipal demand would be reduced substantially (Table 11-15). Because municipal demand must be met primarily with renewable supplies, this population change has a relatively small impact on cumulative groundwater use and actual and accounting overdraft.

Municipal demand for recovery of CAP credits will be determined on a year-to-year basis by water providers. If CAP credits were used to meet 100 percent of potable demand by large water providers in 2025, municipal demand in that year would not change, but actual groundwater overdraft would be reduced while accounting overdraft would not change substantially. Cumulative groundwater savings from 1995 to 2025 would be substantial if CAP credits were used to meet 100 percent of potable demand as soon as the assured water supply requirements took effect.

TABLE 11-15
RESULTS OF HYPOTHETICAL CHANGES OF SELECTED VARIABLES ON OVERDRAFT IN 2025
TUCSON ACTIVE MANAGEMENT AREA

Variable Values in 2025	2025 Sector Demand (AF)	Change in Sector Demand (AF)	1995 - 2025 Cum Grw use by Sector (AF)	Change in Cum Grw Use (AF)	2025 Actual Overdraft (AF)	Change in Actual Overdraft (AF)	2025 Accounting Overdraft (AF)	Change in Accounting Overdraft (AF)
Municipal Population								
1,000,000	200,400	-46,900	2,540,950	-105,500	44,400	-6,000	10,500	3,600
1,266,500, TMP	247,300	0	2,646,450	0	50,400	0	6,900	0
Municipal CAP Credit Recovery								
183,400 AF, 100 % of potable	247,300	0	1,917,950	-728,500	11,700	-38,700	5,200	-1,700
146,370 AF, TMP	247,300	0	2,646,450	0	50,400	0	6,900	0
Municipal Effluent Recharge								
0 AF of effluent recharge	247,300	0	2,646,450	0	8,100	-42,300	-35,400	-42,300
83,000 AF constructed effluent recharge	247,300	0	2,646,450	0	92,600	42,200	49,100	42,200
83,000 AF managed effluent recharge	247,300	0	2,646,450	0	50,400	0	6,900	0
IGFR Acreage								
9,000 acres, reduce 75%	42,900	-27,100	1,459,950	-1,200,250	27,600	-22,800	-15,900	-22,800
18,100 acre, TMP	70,000	0	2,660,200	0	50,400	0	6,900	0
Direct Effluent Use by Agriculture								
28,200 AF, SOI effluent	70,000	0	2,093,200	-567,000	35,800	-14,600	-7,700	-14,600
3,000 AF, TMP	70,000	0	2,660,200	0	50,400	0	6,900	0
Mining Demand								
24,000 AF, 1987 demand	52,400	-23,000	1,497,150	-637,000	30,200	-20,200	-13,300	-20,200
47,000 AF, TMP	75,400	0	2,134,150	0	50,400	0	6,900	0
Mine CAP Use								
10,000 AF direct CAP; rest groundwater	75,400	0	1,859,150	-275,000	40,400	-10,000	-3,100	-10,000
47,000 AF groundwater, TMP	75,400	0	2,134,150	0	50,400	0	6,900	0

AF = acre-feet
TMP = Third Management Plan
IGFR = Irrigation Grandfathered Right
Cum Grw = cumulative groundwater
CAP = Central Arizona Project
SOI = Secretary of the Interior

The impact on overdraft of changes in municipal effluent use approaches reflect the complexity of relationships between direct use of effluent, incidental recharge of effluent, and recharge of effluent through managed in-channel or constructed basin recharge with later recovery of effluent credits. If effluent was not subject to recharge and recovery, actual and accounting overdraft would be substantially lower in 2025. Conversely, recharge of effluent through the use of constructed basins results in a substantial increase in actual and accounting overdraft in 2025. These changes are the result of variations in incidental recharge volumes and cuts to the aquifer that result from these different effluent use approaches. Recovery of effluent credits was not projected to increase for the municipal sector under this sensitivity analysis.

Future reductions in IGFR acreage will be a function of urban development patterns in agricultural areas of the AMA. If, by 2025, acreage decreased by 75 percent from its level in 1995, this would result in significant reductions in sector demand, actual overdraft, accounting overdraft, and cumulative groundwater use by this sector compared to the 50 percent acreage reduction assumed in the Third Management Plan. The direct use of 28,200 acre-feet of effluent by the agricultural sector with no corresponding accrual of credits through, for example, a groundwater savings project, also results in substantial reductions in actual and accounting overdraft and cumulative groundwater use.

Mining demand fluctuates with worldwide market conditions, local ore quality, and the state of mining technology, among other factors. If mining demand were to return to the low water use levels experienced in 1987, sector demand, cumulative groundwater use, actual overdraft and accounting overdraft would all decrease significantly. The direct use of 10,000 acre-feet of CAP water by metal mines would not change sector demand but would result in decreases in the other factors.

11.6.3 Factors Affecting the Ability to Reach and Maintain Safe-yield

Some of the factors that influence the AMA's ability to achieve safe-yield are affected by mandates of the Code. These include conservation requirements, the AWS Program, AWBA efforts to store excess CAP water, and incentives for use of renewable supplies. There are a number of factors that affect safe-yield that are not under the control of the Department. Many of these factors relate to CAP water utilization while others relate to pricing, municipal growth, changes in land utilization, and industrial demand. The impacts of factors that are not under departmental influence vary depending on the time frame in which they are viewed.

Conservation requirements specified in this and subsequent management plans will need to become increasingly stringent to reduce water demand particularly in the agricultural and industrial sectors since these conservation requirements have a direct effect on both actual and accounting overdraft calculations. The Department will prepare additional conservation requirements in the fourth and fifth management periods.

Regardless of these conservation requirements, some volume of groundwater will need to be pumped on an ongoing basis to meet the demand for the 1995 population of municipal users who do not obtain water from designated water providers. Additionally, groundwater will continue to be pumped to meet established grandfathered rights under the Code and allowable groundwater use under the AWS Rules. These continued uses could result in further depletion of groundwater supplies and resultant aquifer compaction and land subsidence. This problem could be mitigated to a certain extent by the purchase and retirement of grandfathered water rights and by managing critical areas of the AMA to prevent damage from further water level declines. In addition, it may be prudent to examine the potential need for replenishment requirements for some of the existing groundwater uses that currently do not have these requirements.

There is currently a surplus of available CAP water due to excess supply on the Colorado River. Storage of excess water in the near term will make it available during future shortages. This is one of the goals of the AWBA. In addition, the AWBA can recharge CAP and extinguish the associated credits to provide water to the aquifer itself. The AWBA is mandated to continue only through 2017. Possible future strategies could be to extend the mandate of the AWBA for more years or increase the groundwater withdrawal fees, which could be used to purchase and recharge CAP water and extinguish the credits.

The ultimate capacity for CAP recharge in the AMA depends on multiple physical, economic, and political variables. Pricing of CAP water is controlled by the CAWCD and is slated to increase with time. CAP terminal storage is necessary if direct use by the City of Tucson or other water provider is to occur at some point in the future, but funding for this project has an uncertain future. Potential treatment processes are being investigated that might be capable of providing CAP water at an acceptable quality for direct use, but the costs could be very large. Besides the CAP allocations held by water users in the AMA, some additional CAP water could become available as a result of resolution of the Southern Arizona Water Rights Settlement Act (SAWRSA). This water could be used by non-Indian users through arrangements made with the Indians to lease supplies or purchase recharge credits. Any assumptions made about CAP water either for direct use or for recharge and recovery must take into account predicted shortages on the Colorado River.

Other diverse factors will affect AMA water use in the next 25 years. The price of potable water is controlled by water providers and the Arizona Corporation Commission and is affected by the cost of energy, infrastructure needs, and other factors. Population growth can lead to retirement of agricultural land and replacement by housing, but can also result in higher water demand to support industries and increased municipal demand. The ongoing demand of the metal mining industry and continued growth of the turf industry are likely to result in increasing water demand by the industrial sector.

Beyond the year 2025 and into the latter part of the next century, it is anticipated that some general trends in water supply and demand could appear. Agricultural production is likely to continue to decrease but may not disappear since some farmlands are in the floodplain and may never be developed. Metal mining could decrease substantially and eventually disappear as the ore bodies at AMA mines are gradually exhausted. Conversely, water use by other industries served by grandfathered groundwater rights and permits could increase in the long run. Municipal water use is likely to continue to increase throughout the next century, further increasing the need for renewable water supplies in the AMA. Effluent is a key water supply that is constantly regenerated within the AMA. In the long-term, increased direct use of effluent could occur if it were treated to potable standards and delivered for direct potable use. The obstacles in terms of public acceptance of this strategy would be substantial.

The decisions made by municipal water providers in the next 25 years will be affected by the long-term water use strategies needed to address the requirements of the AWS Program. These strategies will include their decisions about the use of allowable mined groundwater, recharge and recovery of CAP water, recharge and recovery of effluent, and possible acquisition of additional CAP credits that may become available through agreements with the Tohono O'odham following resolution of SAWRSA. The physical availability of groundwater may increasingly affect water management decisions in the future. Tucson Water is already experiencing problems with decreasing productivity of wells due to water level declines. The declining groundwater levels could make recovery of CAP or effluent credits through groundwater pumping difficult or impossible in some areas of the basin. The Department's computer model will be a valuable tool for evaluating the possible effects of various recharge and pumping scenarios inside the AMA.

11.7 CONCLUSIONS

The last decade has seen rapid changes in water resources management strategies in the Tucson AMA. Assumptions about direct delivery of CAP water made in the Second Management Plan have been reevaluated due to the emergence of difficulties resulting from direct delivery of CAP water and subsequent adoption of the 1995 WCPA. The water budgets presented here indicate that given current projections, **actual groundwater overdraft will continue and the AMA may not reach safe-yield by 2025.** Additional conservation measures and water supply augmentation will be needed in the fourth and fifth management periods to address the shortfall but will only be part of the effort needed to achieve and maintain safe-yield. A variety of additional factors will affect whether safe-yield can be reached, including CAP and effluent recharge and recovery strategies selected by municipal water providers, strategies for the use of allowable mined groundwater, changes in population, agricultural acreage retirement, changes in mine production, changes in demand for other industries, possible increases in CAP supply as a result of Indian water supply settlements, and many others.

The AWS Program addresses the availability of water supplies for 100 years into the future. This 100-year period moves forward as time passes, so in 2050 the 100-year period will extend to 2150. The goal of the AMA is to reach a balance between the use of renewable supplies and diminishing groundwater supplies in order to prevent ongoing mining of the aquifer, and to maintain this balance through time. This balance will be reached only after a transitional period. The volatility of current water use plans reflects this transition and makes the projection of water use difficult.

The water budget is a useful planning tool that needs to be viewed in the long-term planning context. Water management decisions made in the next 25 years will increasingly reflect the need to balance current demands with the anticipated needs of future water users. The water budget will continue to be updated throughout the third management period as new data and water use plans become available. Water budget updates will be coordinated with the computer modeling efforts of the Department so that changes in supply and demand can be understood in terms of their impacts on water levels and subsidence in the AMA. In this way the water budget will continue to be a key tool in understanding the progress the AMA is making toward reaching and maintaining a balance in its groundwater supplies.